VOL. II. DECEMBER, 1896.

Established by **BENJAMIN SILLIMAN** in 1818.

THE

AMERICAN JOURNAL OF SCIENCE.

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FOURTH SERIES.

VOL. II—[WHOLE NUMBER, CLII.]

No. 12.—DECEMBER, 1896.

WITH PLATE VI.

NEW HAVEN, CONNECTICUT.

1896.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 125 TEMPLE STREET.

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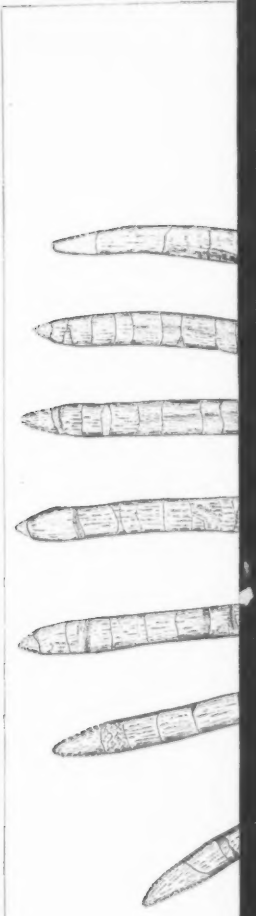
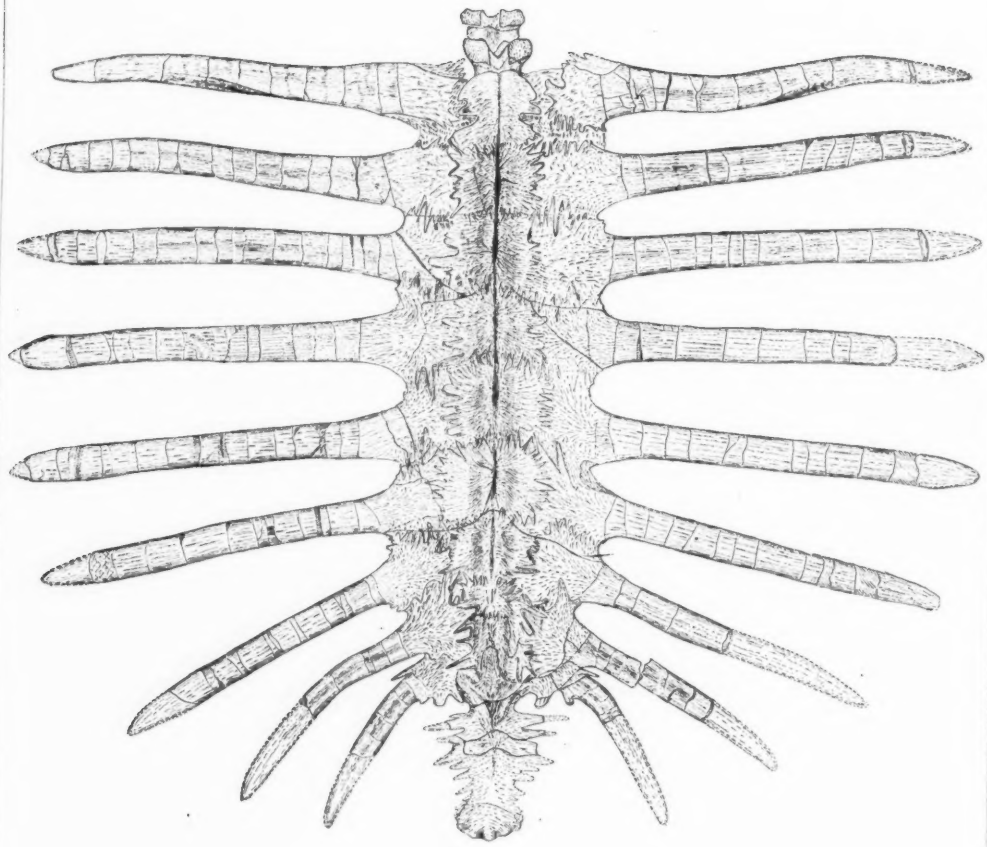




ARCHELON ISCHYROS.

Carapace and ribs showing first dorsal and last cervical centra.
One-fifteenth natural size.

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. LVII.—*Archelon ischyros: A new gigantic Cryptodire Testudinate from the Fort Pierre Cretaceous of South Dakota;* by GEO. R. WIELAND. With Plate VI.

ALTHOUGH it is now some twenty years since Cope first described the genus Protostega, little or nothing has been added to our knowledge of it by the description of new American species. And save the Italian Protosphargis of Capellini this branch of the Sphargididæ has remained a quite isolated one.

I, therefore, propose to describe at this time certain portions of a new gigantic testudinate closely allied generically, from the Fort Pierre Cretaceous of South Dakota, for which the name *Archelon ischyros* is proposed.

The skeleton consists of carapace complete with ribs nearly entire, the procoraco scapulars and coracoids, one humerus complete, both femurs, radius and ulna, tibia and fibula one each, a number of carpals and tarsals, a number of phalanges, most of the cervical and caudal vertebræ, all the dorsal vertebræ, the pelvis entire, a nearly or entirely complete set of spine set plastral shields, fragmentary marginals, and certain bones whose reference has not as yet been decided upon.

As all the larger bones were found in place and the material for a restoration is so exceptional,—one will be given in a short time.

General description.

Carapace.—The carapace is composed of nine pairs of pleuralia, and eight medial pairs of plates or neuralia, followed by one single medial plate and the pygal, or 36 in all. These plates are all very thin and of finely striate surface. They unite very

imperfectly by means of loosely doubled interlocking and overlapping digitations grading into frequent free spines posteriorly. These digitations are mostly long, thin and ribbon-like, and produce a junction quite different from the usual suture. In many cases there is an appearance such as would result if the digitations of the one plate had lain upon the surface of the adjoining plate when it was in a plastic condition and thus raised rounded ridging about their edges. The order of the digitations and their size is rather irregular.

With the exception of the medial pair of plates corresponding to the eighth dorsal vertebra and the single medial following, which are small and crowded, and the pygal, which is comparatively large and heavy, the plates of the carapace are quite regular in size. The width and thickness are quite the same throughout, with a shade more of development of both in the pelvic region. One of the chief features of the carapace is the arching into a heavy dorsal ridge, beginning just back of the region of the first dorsal vertebra, and from thence continuous, except in the sacral region. It marks the position of the neural spines, and is very distinctly grooved from anteriorly to the region of the eighth dorsal vertebra. Immediately over the neural spines this groove inclines to widen, deepen and send out asteriations. In life, these grooves were no doubt filled with horny material, and the animal may have borne a dorsal row of spines. It is the appearance along this groove that makes me regard the medial carapace as consisting of a double row of plates. If these are not to be regarded as separate ossifications, the whole number of plates would be 28, consisting in the nine pairs which are morphologically* simply uncinoid expansions of the ribs, and a medial row of plates, ten in number. I shall have more to say about the carapace at a subsequent time. It consists of very thin, but dense and splintery, bone imbedded in exceedingly hard, indurated marl. In one section, through the medial dorsal ridge just back of the third rib, there is a large open space above the centrum, the thickness of the carapace being in no place much over ·5^{cm}. At another break, exposing in section more nearly through the end of a centrum, back of the sixth rib, the outer carapace may be said to form a very open V, consisting of very thin layerings, while there is a very thin laminated to honeycombed connection with the summit of the underlying neural spine ·3^{cm} in thickness by 1^{cm} in vertical height. There is a tendency to very small thin and irregular bony projection from both bases of this connection. In the

* On relation between carapace and endoskeleton, see Baur, Science, March 23, 1888; also a much more extended treatment in the Biologische Centralblatt, Nr. 5, 6, 1889 (Erlangen).

pelvic region the connection between the carapace and neura spines is no more than one of contact, while in the sacral and caudal regions there is no connection whatever.

Measurements of Carapace.

	Meters.
Total length of portion preserved (exclusive of nuchal and part of pygal)	1·515
Estimated total length, exclusive of nuchal	1·70
Breadth between 2nd and 3rd ribs	·40
" " 5th and 6th "	·40
" " 6th and 7th "	·45
" " 7th and 8th "	·36
" " 8th and 9th "	·28
Narrowest portion of pygal anteriorly	·10
Thickness of carapace	·002–·015

Ribs.—The ribs, of which there are nine pairs, are remarkable for their distal increase in thickness, only 2·5^{cm} in thickness at the edge of the carapace; the distal two-thirds of their length is very massive. In the five anterior pairs the thickness three-fourths out, that is at 75^{cm} from the centra, is from 4 to 5^{cm}. The width is quite regular, and the surfaces, for the four-fifths of the length free from the carapace, is markedly striate longitudinally. In cross section the ribs are T-shaped as they emerge from the carapace, medially they are triangular merging into flattened elliptical distally. The two anterior and two posterior pairs have shallow longitudinal grooving on their upper surface.

In cross-section the ribs show, following a very thin, dense outer layer of bone, a concentric lining, grading into a somewhat spongy interior.

Measurement of Ribs.

	Meters.
Length of 1st rib	·95
" " 2nd "	1·01
" " 3rd "	1·02
" " 4th "	1·02
" " 5th "	1·01
Average thickness of above ribs as they emerge from carapace	·025
Thickness of third and fourth ribs half way out,	·05
Width half way out, 1, 2, 3, 4, 5, 6, 7, 8, 9, respectively, ·075, ·075, ·078, ·075, ·07, ·065, ·06, ·055, ·05.	

Vertebral Column.—Five of the cervical centra with three arches were recovered, the last three being in place. The neu-

ral arches articulated with the centra, and were X-shaped bodies with spreading feet which stood well forward on the centra. Subquadrilateral projections extending well forward bear the prezygapophyses, which are somewhat broken away, but seem to have looked forward rather than upward. Immediately over the neural canal the neural spine retreats rather sharply, at the same time taking a keel shape anteriorly, but posteriorly dividing and spreading out into alæ, which form a distinct deep pit and bear on their under surfaces the postzygapophyses. Posteriorly, there is a groove connecting this cup with the neural arch. Anteriorly, the neural spine does not fork as distinctly above as in the very similar vertebræ of *Protostega gigas* Cope.*

The centra are very heavy and strong bodies, and indicate a neck of enormous strength. They are procœlous, and flat in front, except for the articulating concavity. The anterior upper half rises collar-like on either side of the neural canal, forming an upward and forward-looking articular surface, on which rests the base of the neural arch. The neural canal is scooped out very deeply, and as there is a somewhat similar longitudinal cavity on the nether side, the vertical distance through the centrum is considerably lessened. There are also two similar cavities beneath on the sides, with a heavy ridge, with convex edge, between these and the ventral cavity. Leading from the two lateral concavities around to the neural concavity is a very distinct groove, getting shallower just as it reaches the upper face.

Measurements of 3rd or 4th Cervical Vertebra.

		Meters.
The centrum.		
Length		·095
Width		·140
Diameter of anterior concavity	vertical	·065
	horizontal	·08
Diameter of posterior convexity	vertical	·08
	horizontal	·10
Depth between cup of neural canal and nether groove		·06
The articulating neural arch.		
Total length		·122
Basal width (total)		·11
Width between the bases		·045
Width at top		·075
Distance from base to summit of neural canal		·065
Total vertical depth of neural canal		·08

* Cretaceous Vertebrata of the West, Plate XI, fig. 5 *a*, *b*, *c*, *d*.

The *dorsal vertebræ*, ten in number, have not as yet been completely examined. They present, inferiorly, a striking resemblance to those of *Protosphargis* as restored by Capellini, but with this important exception: in *Protosphargis* the third dorsal vertebra is the largest, in *Archelon* the sixth is by far the largest.* They have nearly, or wholly, flat ends. The neural arches are evidently rather flat bodies, articulating with the centra and forming the heavy dorsal ridge mentioned before. They have little or no connection with the carapace. The dorsal centra increase in size to the sixth. The seventh, eighth and ninth rapidly diminish to the sacral, which are short and flat, and three in number. Following the sacral were five or more *caudal vertebræ* with articulating neural arches, and then fully ten whose arches, like those of the cervical vertebræ of *Protosphargis* and unlike the caudal vertebræ of *Sphargis*, were homologous parts of the centra.† Presumably these were situated beyond the pygal. Of these caudal vertebræ, ten or more were recovered, wholly or in part.

Coracoid.—The coracoid is a shapely and comparatively slender bone, 77^{cm} in length. The lateral surface is finely striate, with larger parallel striations distally. The articulating surface is very distinctly tuberculated, some of the tuberculations being somewhat rounded, others quite conical and so much as 1^{cm} across at base and 1·5^{cm} high.

The articular face is strongly convex anteroposteriorly, and a little less so laterally, but in such manner that near the outer edge of the surface for the procoracoscapula there is a slight concavity, while the humeral surface is broadly flat and looked well downward and forward. For the first two-fifths of its length the shaft is in section isosceles right triangular, with the right angle on the inner side. The upper inner side of the shaft, however, takes a long turn to the outer face just beyond the middle, leaving the distal end comparatively thin and flat. The coracoid is much larger than in *Protostega*, as are all the bones, but bears strong resemblances.

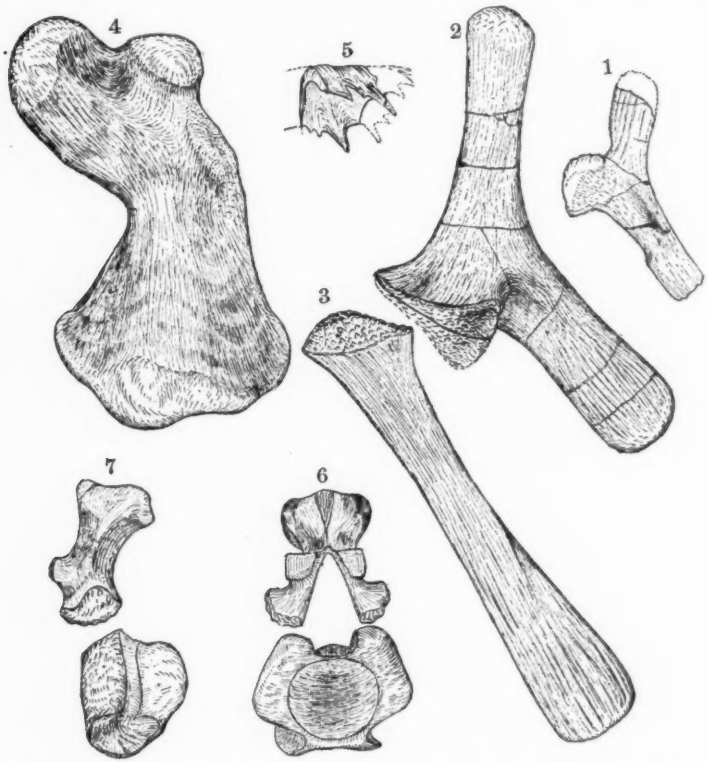
Measurements of Coracoid.

	Meters.
Greatest length	·77
Greatest distal width	·142
Least circumference of shaft	·25
Greatest length of articular face	·20
Greatest breadth of articular face	·145

* Il Chelonio Veronese, Reale Accad. dei Linci, 1883–4 (Rome).

† See the beautiful memoir,—Osteologie du Sphargis Luth. (Sphargis coriacea) par M. Paul Gervais, pp. 199–227 Planche V.—VIII. Nouvelles Archives du Museum, Tome 8, 1872 (Paris).

Procoracoscapular.—The procoracoscapular strongly resembles that of *Protostega*, the chief differences being that while the scapula of *ischyros* is rotund on the outer side, that of



PROTOSTEGA GIGAS Cope.—1. Right Scapuloprocoracoid, one-tenth natural size. And from same individual as Plate VI.

ARCHELON ISCHYROS.—2-7. All from the same individual as Plate VI, and one-tenth natural size, except 6 and 7, which are one-sixth.

2. Left Procoracoscapular, approximate outer view.
3. Left Coracoid Procoracoscapular, approximate outer view.
4. Left Humerus, inside view.
5. Portion of a Marginal.
6. Third or fourth Cervical Vertebra, front view.
7. The same, side view.

Protostega has a well-marked longitudinal depression near the middle and a shoulder-like expansion of the outer edge of the distal end. On the contrary, however, while the shaft of the procoracoid of *Protostega* is quite regular in outline, that of

ischyros bears an elongate ridge just opposite the coracoid border. The scapula and procoracoid stand at the same angle of 125° in both cases. Distally, both these elements are subtriangular in section, with the vertices well on the inner side, leaving the inner faces somewhat ridged distally, though medially there is very distinct flattening.

The outline of the articular face is approximately that of an isosceles trapezoid, with a broadly saddle-shaped convexity angling across it so as to leave on the one side of the upper and wider end of the articular face a concavity for the reception of the coracoid, and on the other side a broad, rather flat, humeral expanse. The entire articulating surface, like that of the coracoid, is tuberculated. The lateral surfaces are finely striate, the procoracoid having additional large striations, like those of the coracoid.

Measurements of Procoracoscapula.

	Meters.
Width of neck	·171
Width of articular extremity	·21
The greatest transverse width of same	·13
Length of precoracoid to inferior border of the scapula	·35
Length of scapula to inferior border of the precoracoid	·485
Length of the scapula to the glenoid cavity	·45
Distance between extremities of the scapula and precoracoid	·66
Width of precoracoid proximally	·117
Least width of precoracoid	·107
Distal width of precoracoid	·127
Distal thickness of precoracoid	·10
Least width of scapula	·078
Proximal thickness of scapula	·046
Distal width of scapula	·095
Distal thickness of scapula	·085

Humerus.—The humerus agrees with that of *gigas* in that it is flat, with a heavy globular head and an immense trochanter, which, with its base, is even larger than the head. In fact, though the head possesses a large articular surface, its general aspect is that of being a secondary projection from the trochanter. From the massive proximal end the shaft constricts slightly near the middle, at the same time flattening, but again expanding and thickening in the lower half into a flat, but massive, fan-shaped distal extremity, making an angle of about 105° with the proximal end. The most notable variation from *gigas* (also *tuberosa*),* aside from dis-

* Cretaceous Vertebrata of the West, p. 113.

parity in size, is in the minor development of the small trochanter, which is little more than a rugosity for ligamental attachment. It is 17^{cm} long and 11 wide, and subovoid in shape with the greatest expansion above, and slight concavity on its inner and obliquely upward facing expanse. The general aspect is, however, moderately convex, owing to a heavy, oblong ridge which crosses obliquely from the upper, outer portion to the lower, inner edge. In *gigas* the small trochanter is prominent, being set on an ala 8^{cm} in length and nearly 2·5^{cm} in height. The bases, therefore, bear out the general proportions of the two bones.

The bicipital groove is a wide and heavy channel, much more marked on the inner side, where it expands into a subovoid concavity whose greatest depth is about 2^{cm}. The inner surface of the fan-like distal end is longitudinally concave, both anteriorly and posteriorly, while the central portion forms a massive, expanding convexity, terminating in the articular face.

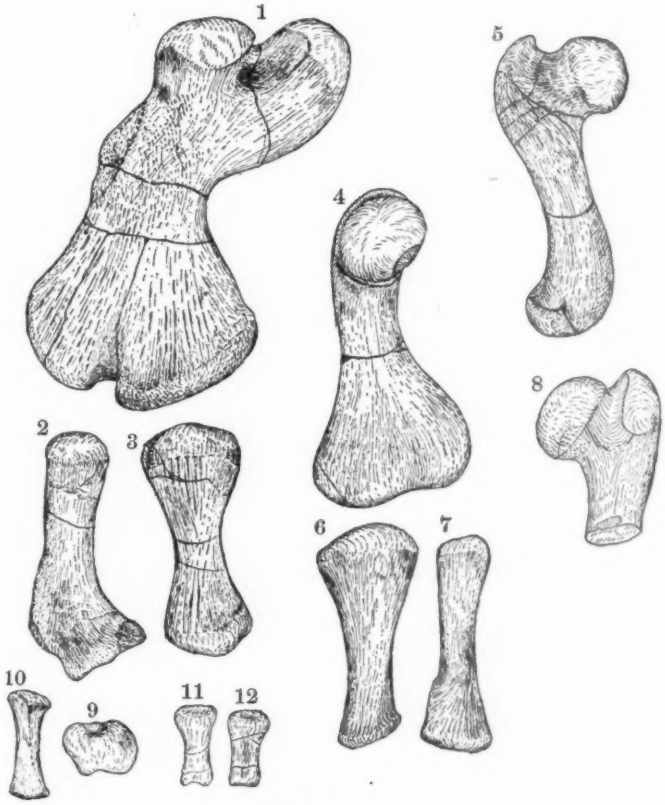
The outer surface is very flatly convex, and conspicuous for a deep groove 5^{cm} wide and 4^{cm} deep, as it ends in the articular surface. The posterior border of this groove lies in the exact distal center. The distal articular surface shows no very distinct divisions. It is both laterally and anteroposteriorly convex, and mostly posterior to the great distal groove, and the centrally place enlargement of the inner aspect which receives it. The surface of the humerus is covered with minute striæ, with larger striations, about 1^{mm} wide and several centimeters long, at short intervals. (Of the humeri, the left is entire, but only the distal third of the right was procured.)

Measurements of Humerus.

	Meters.
Greatest length	·65
Length from head	·58
Width at head, antero-posterior	·28
Greatest circumference about base of the head	·50
Circumference of great trochanter	·45
Least width of shaft	·17
Least thickness of shaft	·09
Circumference at least width of the shaft	·435
Greatest distal width	·34

Ulna.—The ulna is short and comparatively massive, but lacks the immense proportions of the humerus. The proximal articular surface is large and quite regular in outline, flat from side to side, and moderately convex antero-posteriorly (see dimensions). Anteriorly the proximal end bears a broad and shallow groove, disappearing at the middle of the shaft and

reappearing distally as a distinct concave expansion looking forwards and downwards as it rather abruptly merges into the articular surface. The bone has a distinct twist, the trend of the distal articular surface standing at an angle of 75° to that



ARCHELON ISCHYROS.

All one-tenth natural size and from the same individual as Plate VI.

1. Left Humerus, outer view.
2. Left Radius, outer view.
3. Left Ulna, outer view.
4. Left Femur, outer view.
5. Left Femur, anterior lateral view.
6. Right Tibia, outside view, drawn as the left tibia.
7. Right Fibula, outside view, drawn as the left fibula.
8. Proximal of Femur, posterior view.
9. Carpal (?)
10, 11, 12. Phalanges.

of the proximal. The articular surfaces are in area and outline nearly similar, except that owing to the concavity just mentioned the distal face is very slightly crescentic. In its general aspect it is concave and divided by a saddle-shaped antero-posterior ridge into two subequal areas, the exterior and smaller being somewhat elliptical, the interior and larger double concave in outline.

The surface striations are not so distinct as those of the humerus, tending to flatten and interlace. There is very slight pitting and grooving with a tendency to fluting at the extremities, especially the distal. When closely examined with a reading glass the surface is found to be quite ornate.

The ulna is a very compact bone of great strength and the unequal size as compared with the humerus is apparent rather than real. Taken as a homologous part of the huge forelimb that formed the propeller of the largest known marine testudinate, it was admirably adapted to its purpose.

Radius.—The radius, like the ulna, is short and its peculiar distal bow served to give width to the forearm without reducing its strength. The outline of the distal articular surface is that of an isosceles right triangle with the vertex external. It is but slightly concave centrally.

The surface is like that of the radius except along the anterior edge, which is slightly rugose along its entire length.

The set of the distal faces of the radius and ulna was slightly toward each other and they formed a strong base for the massive carpals. Of these one is figured. The phalanges recovered are not of unusual length. Several are figured.

Measurements of the Ulna.

	Meters.
Length	·33
Proximal diameters	·088 and ·138
Least diameters of shaft	·054 and ·063
Distal diameters	·093 and ·14

Measurements of the Radius.

Length (greatest)	·35
Proximal diameters	·049 and ·088
Distal diameters	·082 and ·114
Least diameters of shaft	·05 and ·067

Femur.—The femur is proportioned to the humerus as in *Thalassochelys caretta.* The head stands out at a full right angle on a heavy neck, high and prominent, the articular surface being very convex ovally, the largest diameter bearing an angle of about 45° to the main axis of the humerus. The great trochanter rises well above the head as a somewhat semi-

ovoid projection whose inner boundary as seen from above is a very shallow sigmoid curve. The trochanteric fossa is narrow and deep posteriorly, but widens and becomes slightly shallower immediately in front of the head, again narrowing and disappearing just beneath the head. Just above the most constricted portion of the shaft on the outer side is a lesser trochanter. It is merely a slight inconspicuous convexity. The distal extremity is broad and heavy with a marked downward turn. It is very regular in outline, the external and internal condyles being nearly equal and the intercondylar fossa very shallow. The surface of the bone, like that of the humerus is striate, the striations being most marked distally, with slight longitudinal pitting.

Measurements of left Femur.

	Meters.
Extreme length	·46
Diameters of head	11·5 and ·129
Diameter of neck	9·8 and ·11
Transverse distance through great trochanter	·185
Least diameters of shaft	·075 and ·095
Greatest distal breadth	·23
Greatest distal thickness	·105

Tibia.—The tibia is nearly as large a bone as the ulna, fully as large proximally. There are two slight concavities in the proximal articular face for the reception of the femoral condyles. These are separated by a triangular convexity heaviest on the outer side. The outline of the articular face is that of an ellipse very distinctly flattened on the inner side. The distal articular face is flatly convex and broadly elliptical in outline. It is expanded into a kind of collar or foot for the shaft.

Measurements of left Tibia.

	Meters.
Length	·33
Antero-posterior length of proximal articulating surface	·15
Transverse measure	·10
Least diameters of shaft	·042 and ·061
Diameter of distal extremity	·105 and ·109

Measurements of left Fibula.

Length	·31
Greatest proximal diameters	·082 and ·085
Least diameters of shaft	·035 and ·045
Distal diameters	·108 and ·085

Fibula.—The fibula is a much smaller bone than the tibia proximally, but nearly of the same size distally. The proximal extremity is subquadrilateral in outline with the long side turned to the tibia. Just beneath the articular face in the outer side there is a broad longitudinal scallop. Distally the bone expands, and the articular face is somewhat convex, and elliptical in outline, with a notch for the articulation with the tibia. These two bones have some resemblance to the tibia and fibula of *Protosphargis*.

Dimensions.

The very great width of *Archelon* as compared with either *Protostega* or *Protosphargis* will have been noticed. The ribs in the middle dorsal region are quite exactly 1^{m} in length; adding 13^{cm} as the approximate width of the centra, and 12^{cm} as the additional width due to the marginals, assuming them to have been present, we obtain a total width of 2·25^{m}; that is of more than 2^{m} after making full allowance for dorsal curvature, which must have been slight. If proportioned then as in *Thalassochelys caretta* the total length would be 11 feet. From the vertebral column the same length is indicated. From the five cervical vertebræ the average length would seem to be 9^{cm}. These vertebræ must have supported an enormous head, so that ·60^{cm} is certainly the lowest cranial length that can be assigned. The caudal vertebræ are estimated at ·70^{cm}; that is:

	M.
Cranial length	·60
Eight cervical vertebræ	·72
Ten dorsal "	1·35
Three sacral "	·15
Eighteen (?) caudal vertebræ	·70
	3·52 or 11 ft. 4 in.

This latter will no doubt be a very little less than the actual length.

The most striking feature of this huge animal was formed by the massive forearms, which had a spread of from 16 to 20 feet. Had they had the proportions of *Thalassochelys* the distance would be 20 feet. But there is a wide difference in the structure of the two arms, and I favor the lower estimate.

The length of body I assign to *ischyros* is considerably less than that first estimated for *Protostega* by Prof. Cope and later by Hay on the basis of the hypo- and hyoplastron,* notwithstanding the great disparity in skeletal weight. While it is scarcely permissible to make calculations based so entirely

* Field Columbian Museum Publication 7, Chicago.

upon relations obtaining in different genera, I do think that when a complete skeleton of *Protostega* is once obtained it will be found to lack considerable of the enormous length which has been assigned to it. The cervical vertebra figured by Cope is of much the same size as in *Protosphargis*. Also, as Cope found ten ribs, he must have had at least one approaching the longest in length. From comparison of this kind including *Sphargis* itself, *Protostega gigas* must have been less than three meters in length.

Systematic.

In attempting to place the relationship of *Archelon* in existing classifications we are faced by some very heterogeneous characters.

From the characters which have been given I think it will be accepted that the fossil under consideration stands more nearly on the border line between the two *cryptodire* divisions than any form yet described. The endoskeleton strongly resembles that of *Protostega* and *Protosphargis*, while a connection, though slight, between carapace and endoskeleton points to the *Chelonidæ*. I cannot pass the strong likeness of the shoulder girdle, nor the great similarity in the vertebræ. I would define *Protosphargis*, *Protostega*, and *Archelon* as the gigantic Upper Cretaceous representatives of three genera of the *Dermochelydidæ* with the approach to the *Chelonidæ* in the order named.

Occurrence.

Archelon ischyros was obtained near the South Fork of the Cheyenne River, about 35 miles southeast of the Black Hills in the uppermost Fort Pierre or No. 4 of the Upper Cretaceous. The skeleton lay deeply imbedded at the side of a small ravine, extending out from the base of a butte of typical Miocene. It had formed the nucleus of a lenslike mass of very hard marl. The excavation of the ravine had no doubt broken down the portion containing the head and right forearm but a year or two since. At the time of interment the skeleton may have been subjected to the action of strong currents, coming from the direction in which it headed, as would be indicated by the fragmentary marginals near the head, the absence of smaller bones, phalanges and caudal vertebræ, except somewhat to the rear and beneath, and furthermore to the fact that the third and fourth (?) cervical vertebræ, with their articulating neural arches, were lodged between the carapace and plastron just against the coracoid full two feet out of their

natural position. All this could be due of course to scavengers, but I am strengthened in the opinion that it was owing to currents from the fact that across the Miocene Butte not more than a half mile away, on very much the same horizon, there were several very distinct gravel strata, the gravel ranging in size from one to three inches in diameter.

The vertical section above the position of the fossil was approximately as follows:

Miocene
- "Buttes" with a thickness of from 75 to 100 feet. Flat topped ("railroad buttes," as locally termed because of their embankment-like appearance) owing to a hard flinty to opalaceous layer which caps them. Mostly hard grayish white clays and marls, weathering into red bowlders containing frequent remains of *Testudo*, especially about 30 feet from the summit.

Cretaceous
- Gravelly clays with large flow-and-plunge structure only to be noted in the most favorable positions among the expanse of weathering hills; in most places appearing as a plain gravelly layer one or two feet thick, although the actual thickness is fifteen feet.
- Light red or yellow marly clays containing *Inoceramus*, and very rarely *Baculites*, with frequent masses of septaria, 30 ft.
- Deep red to black "gumbo," 5 ft.
- Thin band of yellow marly clay, 5 in.
- Deep red to black marl or "gumbo," 5 ft.

Underneath the plastron were found four or five species of Mollusca poorly preserved. There were also found in good preservation scales of a fish allied to *Beryx*, also of an unreferred *Malacopterygian*, and a shark's tooth—a very broad-toothed *Lamna*.*

* As a matter of convenience these two references are added: A. S Woodward, On Leathery Turtles Recent and Fossil, Proceedings Geologist's Association, vol. x. Also, Die Chelonier der Norddeutschen Tertiarformation (contains a description of *Pseudosphargis ingens* von Könen) von W. Dames, Palaeontologische Abhandlung, Jena, 1894.

ART. LVIII.—*Examination of Specimens from Chichan-Kanab, Yucatan;* by JAS. LEWIS HOWE and H. D. CAMPBELL.

IN 1894 Mr. E. H. Thompson of Merida, Yucatan, in connection with his archæological researches, collected and forwarded to Prof. F. W. Putnam specimens of water and earth deposits from "the Chichan-Kanab (little sea), an almost unknown lake over six leagues long situated far into the territory of the Sublemdo Indians" in the peninsula of Yucatan. These specimens were placed by Prof. Putnam in the hands of one of us for examination; they were as follows:

"*No. 8.* Specimen of incrustation found twenty yards from present lake edge March 6, 1894."

"*No. 9.* Encountered one foot beneath alluvium deposit half league from foot of Lake Chichan-Kanab."

"*Spec. 172.* Water taken from one yard off shore upper end Chichan-Kanab."

"*Spec. 1189.* Water taken off middle of Lake Chichan-Kanab, State of Yucatan, Mexico."

No. 8 was a light buff crystalline mass which on analysis proved to be gypsum.

No. 9 was a light gray mass resembling dried mud. It was easily friable and could be rubbed in the fingers to a fine powder. This like No. 8 was almost pure gypsum, a small amount of vegetable matter being present. A portion was dissolved in water and two equal portions of the solution analysed, one for calcium and the other for sulphuric acid. 0·0260 grams calcium and 0·0612 grams SO_4 were found. The formula $CaSO_4$ would require 0·0255 grams calcium for 0·0612 grams SO_4. Two grams of the material lost on 22 hours heating at 160° 0·4083 grams or 20·42 per cent. At red heat the total loss was 0·4323 grams or 21·62 per cent. The percentage of water in gypsum is 20·93 per cent. Under the microscope the powder was seen to consist of small crystals.

Regarding this gypsum, Prof. H. D. Campbell reports as follows: The powder consists of lenticular crystals, not rounded grains nor crystal aggregates, nor as far as observed is twinning shown. The largest crystals have a diameter of 0·15^{mm} and a thickness of 0·06^{mm}. The smallest ones still appear as powder under the higher powers of the microscope. The crystals show a more or less hexagonal outline, indicating the presence of prismatic and clinopinacoidal faces. Curved faces run up toward a point and appear to represent the faces of pyramid and dome. When dissolved in water and recrystallized, they assume the more usual forms of gypsum crystals.

Specimen 172. The amount of water in each of the two specimens was less than 350^{cc}, precluding the possibility of a full and accurate analysis. This specimen was perfectly clear and without sediment except a little sand. Without odor and with no perceptible taste. Reaction neutral. On evaporation crystals of gypsum began to crystallize out with slight concentration.

Analysis showed the following per liter:

Ca	0·865 grams
Mg	0·313
K	0·025
Na	0·301
SO_4	3·361
Cl	0·368

From this it appears that the principal salt in the water is calcium sulphate with smaller quantities of sodium sulphate and magnesium chloride.

No other bases or acids were found, and bromine, iodine, strontium, barium, magnesium and iron were shown to be absent by as careful examination as the quantity of water permitted. Organic matter was also absent.

Specimen 1189, water from the middle of the lake, was perfectly clear when opened, with a slight black rather flocculent deposit. It had a strong odor of hydrogen sulphide and a somewhat bitter taste. Reaction neutral. As soon as the odor of hydrogen sulphide was detected it was resealed, but before it could be examined (a few hours) it had given a copious deposit of sulphur.

Hydrogen was then led through the water for eighteen hours, the H_2S not precipitated being absorbed in caustic soda, and estimated as As_2S_3. The precipitated sulphur was recovered as far as possible by extraction with rectified carbon disulphide in which it was soluble. The amounts from 345^{ccm} of water are as follows, calculated per liter:

Hydrogen sulphide dissolved	·01008^{grm}	= 6·64^{ccm}
" " from precipitated sulphur	·03942	25·91
Total hydrogen sulphide per liter	·0495^{grm}	= 32·55^{ccm}

Analysis showed the following per liter:

Ca	0·600 grams
Mg	0·325
K	0·019
Na	0·533
SO_4	2·607
Cl	0·362

Qualitative examination showed results similar to those of the water 172 taken near the shore. While the two waters resemble each other as regards the salts present, it will be noted that the shore water contains decidedly more calcium sulphate, but less sodium. The presence of hydrogen sulphide in the water from the middle of the lake is difficult to account for, unless there may be a sulphur spring beneath the lake at this point. The shores of the lake being so largely gypsum, as appears from the specimens, the water near the shore might take up more of this material, accounting for the increased gypsum content of the shore water over that of the middle of the lake.

The gypsum of the lake shore is quite possibly formed from the evaporated lake water. This appears probable from the fact that the gypsum, deposited on evaporating both waters, contains in addition to the ordinary forms a small proportion of crystals similar to those described above in deposit No. 9. If this is the case it would be interesting to know the origin of the large content of gypsum in the lake water. The shore water is evidently a supersaturated solution of gypsum. On the other hand, the lake may obtain its gypsum from the gypsum deposits of the vicinity. The problem must be considered unsolved until further explorations of the lake are made.

Washington and Lee University, Lexington, Va., June, 1896.

Art. LIX.—*A method for the Separation of Aluminum from Iron;* by F. A. Gooch and F. S. Havens.

[Contributions from the Kent Chemical Laboratory of Yale University.—LXI.]

Of the well-known methods for the separation of aluminum from iron—by the action, for example, of an alkaline hydroxide in aqueous solution or by fusion of the mixed oxide in potassium or sodium hydroxide; by reduction of the iron oxide to the metal by heating in hydrogen, with the subsequent solution of the metallic iron in hydrochloric acid; by boiling the nearly neutral solution of the salts of aluminum and iron with sodium thiosulphate either with or without sodium phosphate; by acting with hydrogen sulphide or ammonium sulphide upon solutions of the salts containing also an ammoniacal citrate or tartrate—no single process can be said to be ideal as regards directness, rapidity and accuracy of working. We have deemed it not superfluous, therefore, to attempt the utilization of a reaction which should apparently be capable of effecting directly and quickly the separation of aluminum from iron under conditions easily attainable.

It is known* that the hydrous aluminum chloride $AlCl_3.6H_2O$ is very slightly soluble in strong hydrochloric acid, while ferric chloride, on the other hand, is extremely soluble in that medium. It is this difference of relation of which we wished to take advantage.

It appeared at the outset that crude aluminum chloride could be freed from every trace of a ferric salt by dissolving it in the least possible amount of water, saturating the cooled solution with gaseous hydrochloric acid, filtering upon asbestos in a filtering crucible or cone, and washing the crystalline precipitate with the strongest hydrochloric acid. Aluminum chloride prepared in this way gave no trace of color when dissolved in water and tested with potassium sulphocyanide. The correlative question as to how much aluminum chloride goes into solution under the conditions was settled by taking a portion of the pure aluminum chloride, dissolving it in a very little water, diluting the solution with strong hydrochloric acid, saturating the cooled liquid with the gaseous acid, filtering on asbestos, precipitating by ammonia the aluminum salt in the filtrate and weighing the ignited oxide.

From 10cm³ of such a filtrate we obtained in two determinations 0·0022 grm. and 0·0024 grm. of the oxide, the mean of which corresponds to 23 parts of the oxide or 109 parts of the hydrous chloride in 100,000 parts of the strong hydrochloric acid. This degree of solubility, though inconsiderable when

* Gladysz: Ber. d. d. chem. Gesell., xvi, 447.

the objective point is the preparation of the pure salt of aluminum, is obviously incompatible with the attainment of quantitative accuracy in the retention of the aluminum. We have found, however, that various mixtures of anhydrous ether and the strongest hydrochloric acid can be used satisfactorily as solvents for the iron chloride, while the aluminum chloride is insoluble to a very high degree in a mixture of hydrochloric acid and ether taken in equal parts and thoroughly saturated with gaseous hydrochloric acid at the atmospheric temperature. We found that 50 cm³ of the solution of aluminum chloride, obtained by mixing about 0·1 grm. of the hydrous chloride (dissolved in 2 cm³ of water) with the mixture of pure, specially prepared aqueous hydrochloric acid and ether in equal parts and again saturating the liquid at 15° C. with gaseous hydrochloric acid, left upon evaporation and ignition 0·0004 grm. in each of two experiments—results which indicate a maximum solubility corresponding to 1 part of the oxide or approximately 5 parts of the chloride in 125,000 parts of the equal mixture of ether and aqueous hydrochloric acid of full strength.

Pure aqueous hydrochloric acid of full strength mixes perfectly with its own volume of anhydrous ether, but it is a curious fact that the addition to this mixture of any very considerable amounts of a solution of ferric chloride in strong hydrochloric acid determines the separation of a greenish oily etherial solution of the ferric salt upon the surface of the acid. The addition of more aqueous acid does not change the conditions essentially, but more ether renders the acid and the oily solution completely miscible. The ferric chloride seems to abstract ether from the ether-acid mixture and, then dissolved in the ether, remains to some extent immiscible with the aqueous acid thus left until the addition of more ether restores to the mixture that which was taken from it by the ferric chloride. Our experiments show that, while for the separation of insoluble aluminum chloride from certain small amounts of solu ble ferric chloride the mixture of the strongest aqueous hydrochloric acid and ether in equal parts serves a most excellent purpose, when larger amounts of ferric chloride are to be dissolved ether must be added proportionately in order to prevent the separation of the ethereal solution of ferric chloride from the rest of the liquid.

Great care was taken to insure the purity of the aluminum chloride used in the test experiments. The so-called pure chloride of commerce was dissolved in the least possible amount of water and this solution was treated with a large volume of strong hydrochloric acid. The chloride thus obtained, free from iron, but possibly contaminated (as we found by expe-

rience) with some alkaline chloride, was dissolved in water and converted by ammonia to the form of the hydroxide, which was thoroughly washed and dissolved in hot hydrochloric acid of half-strength. From this solution, after cooling, gaseous hydrochloric acid precipitated the hydrous chloride in pure condition. The chloride thus prepared was dissolved in water and the strength of the solution was determined by precipitating the hydroxide from definite portions, and weighing the ignited oxide in the usual manner.

TABLE I.

	Al_2O_3 taken in solution as the chloride. grm.	Al_2O_3 found. grm.	Final volume. cm^3	Error. grm.
(1)	0·0761	0·0746	50	0·0015—
(2)	0·0761	0·0745	50	0·0016—
(3)	0·0761	0·0741	50	0·0020—
(4)	0·0761	0·0734	50	0·0027—
(5)	0·0761	0 0756	50	0·0005—
(6)	0·0157	0·0149	45	0·0008—
(7)	0·0157	0·0147	40	0·0010—
(8)	0·0157	0·0144	45	0·0013—
(9)	0·0480	0·0481	30	0·0001+
(10)	0·0960	0·0957	30	0·0003—

In the experiments recorded in Table I, measured portions of the standardized solution were submitted to the treatment with hydrochloric acid and ether. The essential thing in the process is to have at the end a mixture of the strongest aqueous hydrochloric acid with an equal volume of anhydrous ether saturated at a temperature of about 15° C. The most convenient way to secure these conditions seems to be to mix the aqueous solution of the aluminum salt with a suitable volume of the strongest aqueous hydrochloric acid—enough to make the entire volume something between 15 and 25 cm^3—to saturate this mixture with gaseous hydrochloric acid while the liquid is kept cool by immersing the receptacle containing it in a current of running water, to intermix a volume of ether equal to the volume of the liquid, and finally, to treat the ethereal mixture once more with the gaseous acid to insure saturation. The precipitated crystalline chloride was collected upon asbestos in a perforated crucible, washed with a previously prepared mixture of hydrochloric acid and ether carefully saturated with the gaseous acid at 15° C., and either ignited after careful drying at 150° or redissolved in water, converted to the hydroxide by ammonia in the usual way and weighed as the oxide after filtration, washing, and ignition. In experiments (1) to (4) the precipitated chloride was ignited directly; in

experiment (5) the ignition was made with great care in an atmosphere of superheated steam; and in experiments (6) to (10) the chloride was dissolved, precipitated as the hydroxide, and weighed as the oxide.

The experiments in which the chloride was converted to the hydroxide before ignition show upon the average an absolute loss of about 0·0006 grm.; the single experiment in which the ignition took place in steam shows about the same loss—0.0005 grm.; while in those experiments in which the chloride was dried and then ignited directly, the average loss amounts to about 0·0020 grm. The error of the process which involves the precipitation of the aluminum as the hydroxide, falls within reasonable limits, but it is plain that the direct ignition of the chloride is liable to error, which may possibly be explicable as a mechanical loss occasioned by the too rapid evolution of the hydrochloric acid and water of crystallization, or, possibly, as the result of a very slight volatilization of the aluminum still holding chlorine in spite of the decomposing action of the water upon the chloride. In either case, it would seem to be reasonable to suppose that a layer of some easily volatilizable oxidizer placed upon the aluminum chloride might serve to obviate the difficulty—in the one case, by serving as a screen to diminish mechanical transportation of the non-volatile material; and in the other, by acting as an agent to promote the exchange of chlorine for oxygen on the part of the aluminum chloride.

We have tried, therefore, the expedient of covering the aluminum chloride before ignition with a layer of mercuric oxide, which of itself left no appreciable residue when it volatilized. The hydrous chloride was collected as usual upon the asbestos in a perforated crucible, dried for a half-hour at 150° C, covered with about 1 grm. of the pure mercuric oxide, gently heated with great care under a suitable ventilating flue, and finally ignited over the blast. The results are given below:

TABLE II.

	Al_2O_3 taken in solution as the chloride.	Al_2O_3 found by ignition with HgO.	Final volume.	Error.
	grm.	grm.	cm_3	grm.
(1)	0·0761	0·0758	25	0·0003—
(2)	0·0761	0·0754	25	0·0007—
(3)	0·0761	0·0751	25	0·0010—

It is obvious, therefore, that the precipitation of the crystalline hydrous aluminum chloride from solutions of the pure salt is perfectly feasible and very complete, when effected by aqueous hydrochloric acid and ether thoroughly saturated with

the gaseous acid and kept cool; and that the conversion of the chloride into the weighable form of the oxide is best effected by ignition under a layer of mercuric oxide, or by dissolving it in water and precipitating it as the hydroxide to be afterward washed, dried, and ignited. Of the two methods the former is by far the more convenient.

The precipitation of the aluminum chloride in pure condition from solutions containing ferric chloride ought not, it would seem, to present any difficulty, providing only that the precaution is taken to have present a sufficient excess of ether. The question was put to the test of experiment with the results recorded in Table III.

Measured portions of the standardized solution of aluminum chloride were evaporated nearly to dryness in a platinum dish, an amount of pure ferric chloride equivalent to about 0·15 grm. of the oxide was added in a very little water, 15 cm^3 of the mixture of strong hydrochloric acid and ether in equal parts were introduced, the liquid was saturated at 15° C. with gaseous hydrochloric acid (the dish being held in a convenient device for cooling it by running water), 5 cm^3 more of ether were added to secure complete miscibility of the solutions, and more gas passed to perfect saturation. The aluminum chloride was collected upon asbestos in a perforated crucible, washed with a mixture of ether and aqueous hydrochloric acid thoroughly saturated with the gaseous acid, dried at 150° C. for a half-hour, covered with 1 grm. of pure mercuric oxide, and ignited at first gently and finally over the blast.

TABLE III.

	Al_2O_3 taken in solution as the chloride.	Al_2O_3 found by ignition with HgO.	Fe_2O_3 present as chloride.	Final volume.	Error.
	grm.	grm.	grm.	cm^3	grm.
(1)	0·0761	0·0757	0·15	25–30	0·0004—
(2)	0·0761	0·0756	0·15	25–30	0·0005—
(3)	0·0761	0·0755	0·15	25–30	0·0006—
(4)	0·0761	0·0755	0·15	25–30	0·0006—

The results show plainly a very satisfactory limit of error.

ART. LX.—*Chemical Composition of Hawaiian Soils and of the Rocks from which they have been derived;* by A. B. LYONS, F.C.S., Honolulu, H. I.

THE relation in chemical composition of soils to the rocks from which they have been definitely derived, can be studied most easily and profitably in a volcanic country, where disintegration of the rock is rapid and is attended with great chemical changes. I wish to present, as briefly as is consistent with clearness, the result of studies in this field which I have had occasion to make during the past two years. The chemical composition of these volcanic soils is peculiarly interesting and full of surprises to one unaccustomed to their vagaries.

The agricultural analysis of a soil is, of course, not exhaustive. The mineral constituents determined are merely those extracted from the finer portion of the soil by the action for a definite time of a specified solvent, generally of hydrochloric acid, of sp. gr. 1·15. The solvent is commonly allowed to act from three to five days. I found by experiment that the boiling acid would extract from the fine soil practically all that is soluble in two hours, except in the case of some of the very new soils, and in the analyses here reported this method of extraction was adopted, except in the first two, where a longer time (three days) was taken. In the estimation of phosphoric acid, however, nitric acid was used as a solvent, according to the usual practice. The residue after treatment with hydrochloric acid was found to consist almost wholly of silica and titanic acid. It contained little iron, calcium or magnesium, but retained considerable potassium and sodium, sometimes as much as eighty per cent of all present in the soil. These facts must be borne in mind in making comparisons of the soil analyses with the complete and exact analyses I have to report of the rocks from which the soils have been derived.

In order to bring out clearly the comparison between soil and rocks, I have reported the mineral constituents only of the soils in per cent. of the weight of the ignited sample. I have added, however, at the foot of the table figures indicating the percentage loss on drying at 100° C, and further on ignition of the air-dried soil.

Out of a large number of soil analyses I have selected for tabulation some that may be considered representative. The first three are soils derived from decomposition of volcanic sand or ash, spread over the surface of the country by explosive eruptions so recent that only the finer particles have suffered disintegration. These soils are sandy or gravelly, almost

wholly destitute of clay, and contain comparatively little organic matter.* The mineral constituents requisite for plant food are present in extraordinary abundance, especially the phosphoric acid, and yet these soils may be rather easily "exhausted" by loss of their organic matter.

TABLE I. ANALYSES OF HAWAIIAN SOILS. [MINERAL CONSTITUENTS.*]

	New, from lapilli.			New, from lava only partially disintegrated.				Old, from thoroughly disintegrated ancient lava.		
	Punahou, Oahu.	Pahala, Hawaii.	Waimea, Hawaii.	Mollilli, Oahu.**	Hilo, Hawaii.	Hilo, Hawaii.	Ookala, Hawaii.	Ewa, Oahu.	Ewa, Oahu.	Manoa, Oahu.
Al_2O_3†	22·79	12·97	23 97	23·69	22·09	17·84	23·53	27·48	29·06	26·86
Fe_2O_3	24·73	10·93	18 78	29·12	44·85	32·13	34·86	20·31	24·54	29·72
MnO	·20	·03	·29	·46	·10	·29	·34	·15	·11	·18
CaO	5·47	3 44	5·70	·74	·09	·41	·66	·39	·38	·29
MgO	3·62	·73	1·43	1·81	·19	·61	1·07	·23	·28	·74
Na_2O	1·07	·71	·19	1·07	·33	·17	·33	·34	·34	·22
K_2O	·74	·19	·39	·58	·21	·37	·38	·51	·43	·16
P_2O_5	2·92§	·48	6·47¶	·36	·40	·49	·76	·10	·15	·27
SO_3	·18	·05	·27	·10	·16	·11	·49	·07	·06	·08
Soluble SiO_2, etc.	3·23	1·68	2·43	42·48	7·20	4·69	5·45	50·01	44·69	5·31
Insoluble	36·20	68·79‖	39·72		24·39	42·98	33·09			37·24
Organic and combined Water‡	15·10	14·94	29·46	11·88	34·30	14·40	40·80	16·06	17 09	19·77

* Constituents dissolved by boiling two hours with hydrochloric acid, sp. gr. 1·15.
† Figures except in last line are percentages of the ignited soil.
‡ Per cent. of soil dried at 100° C.
§ Phosphoric acid in soils from this region ranges from 1·2 to 2·9 + % of ignited soil.
‖ Contains much undecomposed silicate.
¶ Phosphoric acid in soils from this region ranges from 2·5 to 6·5 per cent. of ignited soil.
** Contains cobalt. Most of the soils contain copper, some of them chromium.

No. 1 is derived from a coarse volcanic gravel (lapilli), thrown out in an eruption so recent that except within a few decimeters of the surface it remains as black and fresh-looking as it ever was. If this soil is passed successively through sieves having respectively apertures 2^{mm}, 1^{mm} and $\frac{1}{2}^{mm}$ in diameter, the first will screen out chiefly fragments of undecomposed gravel, while the second and third will retain coarse sand which will be found to consist almost wholly of crystals, mostly superficially oxidized, of chrysolite. A finer, heavy,

* Owing to the absence of clay, the organic matter present in such soils is liable to be in a remarkable degree combustible.

black sand can be separated by washing, consisting of octohedral crystals, part only of which are magnetic. Under a lens, it will be seen that the crystals of chrysolite are studded also with these iron crystals.

The proportion of phosphoric acid in this soil (nearly three per cent) seems fabulous; what is remarkable is that it is much higher than in any sample I have analyzed of the lapilli whence it was derived.

No. 2 is from a volcanic sand consisting of finer particles, but more resistant to the action of acids, so that the residue on treatment with hydrochloric acid is very large, and obviously retains much base. The chrysolite in this soil is nearly transparent, being scarcely at all oxidized.

No. 3 is an older soil, but derived, I think, from a fine-grained volcanic ash. There is almost no clay, but neither is there much sand. The soil contains few particles exceeding $0{\cdot}1^{mm}$ in diameter; more than half of it is "dust," the particles being less than $.01^{mm}$ in diameter. Analysis indicates that it is derived from a highly feldspathic lava. The figure for phosphoric acid will excite incredulity in others as it did in myself until confirmed by duplicate experiment. The quantity varied greatly in samples of the soil taken from different localities, but in all was absurdly high—much in excess of that found in any sample of the country rock.

The next four samples are derived from the decomposition of comparatively recent lava. Most of the arable soil on Hawaii and much of that on Maui belongs to this class. These soils agree in containing, like those of the first class, much unoxidized iron and a large proportion of phosphoric acid (in no case amounting, however, to as much as one per cent). The proportions of calcium and of potassium are generally not very small, but vary greatly with the climate. When the rainfall is not excessive, these bases are present in good, or even in large, proportion; but in rainy regions, as in the Hilo district, they may be greatly reduced, especially the calcium, as illustrated in sample No. 5 in the table. This same sample is remarkable again for its small content of silica and for its exceedingly large proportion of iron.

The soils of the third class, designated "old," are derived from ancient lavas completely disintegrated. They are distinctly clayey, and of a deep red color, containing very little ferrous iron. The proportion of phosphoric acid is generally smaller than in the new soils and calcium is commonly low, but these clayey soils are not as easily exhausted by careless tillage as the others.

Table No. II gives the results of analyses of a series of representative Hawaiian lavas. No. 1 in this series is especially interesting because it is from this material (lapilli) that the

Punahou soil already spoken of has been derived. It is what is familiarly known in Honolulu as "black sand," used as a dressing for driveways and garden walks. It consists of a black, fresh-looking lava in irregular angular fragments, from one to ten or even twenty millimeters in their several dimensions. Spring water that has leached through this black sand

TABLE II. ANALYSES OF HAWAIIAN LAVAS.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	Av.
	Lapilli. Recent.	Scoriaceous. Recent.	Compact, Feldspathic, Old.	Scoriaceous Vesicular, Old.	Porphyritic, Old.	Feldspathic Large Crystals, Ancient.	Compact, Ancient.	Somewhat Vesicular, Ancient.	Capillary "Pele's hair." Recent.	
	Punahou, Oahu.	Punahou, Oahu.	Waimea, Hawaii.	Waimea. Hawaii.	Kohala. Hawaii.	Waianae, Oahu.	Waianae, Oahu.	Waimeae. Oahu.	Kilauea, Hawaii.	
SiO_2	35·86	36·85	58·06	47·33	49·01	46 30	51·63	49·88	45·79	47·86
TiO_2	2·90	4·05	1·88	4·84	3·93	5·35	2·47	3·97	3·25	3·63
Al_2O_3	12·10	11·97	18·21	17·96	16·29	17·95	12·10	13·79	15.09	15·05
Fe_2O_3	7·82	13·90	4·87	12·64	7·61	6·21	8·67	9·65	5·34	8·59
FeO	8·09	6·54	2·01	·51	4·89	6·79	3·10	2·61	5·58	4·46
MnO	·39	1·13	·36	·64	·27	·26	·30	·67	·49	·50
CaO	12·08	9·00	3·29	6·29	9·79	8·17	9·17	9·59	10·21	8·62
MgO	9·72	10·73	1·59	3·97	3·62	3·67	9·40	6·12	5·92	6·08
Na_2O	6·23	4·13	6·12	3·67	3·82	3·92	3 10	3·30	3·67	4·22
K_2O	1·93	·79	2·75	1·10	·80	·89	·30	·17	·90	1·07
CuO	·25	·10	·10	·15	·10	·17	·48	·14	·18	·19
P_2O_5	1·08	1·25	·65	1.05	·49	·53	·26	·26	·29	·65
SO_3	·27	tr.	·05	·07	·20	·06	·07	·09	2·54‡	·10
S		·14	·05	·07	·02	·05	·03	·02		·11
	FeS 1·40	CoO ·04					Cr_2O_3 tr.	Cr_2O_3 tr.		
Total	100·12	100·62	99·99	100·29	100·84	100·32	101·08	100·26	99·25	
Dried* at 100°. C.		5·48	·53	2·38	·98	1·75	·47	1·84		
Ignited †		4·74	·83	3·08	1·00	2·00	·33	1·14		

* Percentage loss of original air dried powder.
† Additional percentage loss of original powder on ignition.
‡ Derived from exposure to sulphurous fumes, and hence not considered in the averaging.

is charged with sodium carbonate. Acids act very vigorously on the sand, generating much heat and rapidly disintegrating the mineral, with separation of gelatinous silica and evolution of hydrogen sulphide. The lava is evidently an exceedingly basic one, and it is to be observed that it comes from the most

recent eruption of an extinct volcano, whose older lavas are distinctly less basic. The volcano must have been for many ages wholly extinct previous to the period of activity during which this black sand was ejected, in a stupendous explosive eruption, which spread it over an area many square miles in extent, in a stratum from one to fifty meters or more in depth.

The points of interest in the composition of this lava are its low content of silica and the very large proportion it contains of ferrous iron, of unoxidized sulphur and of phosphoric acid.

No. 2 is lava from a cinder cone at the base of the volcano from which the black sand was ejected. The black sand overlies this lava at some points, but I believe that they belong to the same period of volcanic activity, so recent that even in exposed situations the wrinkles and creases, formed while the lava was in a pasty condition as it cooled, remain as sharply defined as ever. The chemical composition agrees in the main with that of No. 1, the differences being, in part, what we might expect from differences in the circumstances of the respective eruptions. Unoxidized sulphur has nearly disappeared, and the proportion of ferrous iron has been greatly reduced, by prolonged exposure of the fluid lava to the air. There are, however, interesting differences in the original composition of these two products of a single volcano, the explanation of which is beyond the scope of the present paper.

The presence in notable quantity of cobalt, and the extraordinarily large proportion of manganese and of phosphoric acid are the points of especial interest. Lavas from Telegraph Hill, three miles distant, nearly or quite as recent, exhibit the same peculiarities in chemical composition. In both localities, incrustations of manganese dioxide occur on rocks that have been submerged.

In No. 3 we have a lava of a totally different character. It is a bluish gray, compact, minutely crystalline lava, containing much feldspar and very little chrysolite, and is the prevailing rock in the Kohala mountain, at least in the Waimea neighborhood. It seems to be similar to the lavas sent to Prof. Dana by Rev. S. E. Bishop, from West Maui, and differs from all other Hawaiian lavas I have analyzed in its small content of iron and of titanic acid.

No. 4 is a highly vesicular, red lava from the ejecta of one of the numerous cinder cones on the Kohala mountain. Here again, in a more recent lava, we find the proportion of bases and that of phosphoric acid increased. It seems probable that the soil No. 3 originated from volcanic ash ejected from these same cinder cones, the proportion of phosphoric acid being there still higher.

No. 5 is also a lava from the Kohala mountain (the oldest of the Hawaii mountains, but recent in comparison with the

mountains of Oahu); a somewhat vesicular stony lava of rather light color, porphyritic with white crystals of feldspar.

No. 6 is a type which I have seen nowhere but on the island of Oahu, and chiefly in the oldest formations of that island, viz: in the Waianae mountains. I should expect to find it also on Kauai, but that island I have not explored. It is highly feldspathic and made up largely of tabular crystals 5 to 15^{mm} long and perhaps 1 or 2^{mm} thick. In superficial portions of the rock, the augitic constituent of the lava is often partially disintegrated, but the specimen analyzed was quite sound. It is especially remarkable for the large proportion it contains of titanic acid. Previous analyses of Hawaiian lavas, I may remark, seem not to have given due attention to this constituent, which in some of them is not even mentioned.

No. 7 is a close-grained dark basalt with a few green crystals of chrysolite, from one of the oldest formations of Oahu. Although taken from a fragment that had been detached from the cliff and had lain for ages where it was submerged at spring tide with salt water, it seemed to have suffered absolutely no change, except superficially, and it may be regarded as a representative specimen of this ancient trap-like basalt. Copper, which is present in all the Hawaiian lavas examined, reaches in this a maximum figure—nearly half of one per cent of CuO.

No. 8 is another representative sample from the lowest beds of the Koolau range of Oahu. It is somewhat vesicular, and has suffered some change probably in the oxidation of a portion of its ferrous iron, and possibly in the loss of some of its potash—I think not to any great extent. This, as well as the preceding specimen, contains chromium, which may have been present in traces in some of the other lavas, as it is not unfrequently present in the Hawaiian soils.

No. 9 is the capillary form of lava known as Pele's hair. Of course it is simply the lava of Kilauea spun into fine threads and so instantaneously cooled. The sample analyzed was, however, not a representative one, for it had been a long time exposed to the sulphurous vapors from Halemaumau, the result appearing in the analysis in its extraordinary content of sulphate. We call to mind in this connection the incrustations, about fissures in Kilauea, of ferric sulphate, and the stalactitic deposits of sulphates of soda, calcium, aluminum and even of copper (curiously enough not often of iron) found in caverns in the crater.

Table III gives the result of analyses of specimens of rock altered by exposure to the weather, and of volcanic tufa. In the former, while titanic acid seems to have been but slightly diminished in amount, there has been a notable loss of silica,

and calcium, magnesium, sodium and potassium have almost wholly disappeared.

TABLE III. ANALYSES OF HAWAIIAN ROCKS, ETC.

	"Rotten" Lava.				Tufa.					
	I.	II.	III.		I.	II.	III.			
	Honolulu, Oahu.	Kaneohe, Oahu.	Hilo Hawaii.	Av.	Punchbowl, Oahu.	Diamond Head, Oahu.	Salt Lake, Oahu.	Av.	Sound Lavas. Av.	Mineral of Soils. Av.
SiO_2	34·81	4·54	24·62	21·32	37·82	40·11	47·44	41·79	47·86	40·00
TiO_2	4·89	8·99	8·12	7·33					3·63	
Al_2O_3	33·18	41·35	23·89	32·81	13·16	12·40	16·51	14·02	15·05	22·59
Fe_2O_3	23·03	40·87	37·85	33·92	14·11	14·64	15·33	14·69	8·59	30·05
FeO	2·34	2·52	2·08	2·31	·14	tr.	3·19	1·11	4·46	
MnO	·28	·08	·25	·30	·24	·25	·37	·29	·50	·21
CaO	tr.	tr	tr.	tr.	13·39	12·24	6·02	10·55	8·62	1·26
MgO	·39	·37	·99	·58	11·75	11·65	8·80	10·73	6·08	1·19
Na_2O	tr.	tr.	1·41	·47	1·66	2·72	1·60	1·99	4·22	·50
K_2O	tr.	tr.	tr.	tr.	1·49	·96	·30	·91	1·07	·43
CuO	·37	·26	·27	·30	·07	·11	·08	·09	·19	
P_2O_5	·39	·63	·24	·42	·82	·57	·61	·67	·65	·68
SO_3	·31	·55	·40	·42	·15	·17	·06	·13	·10	·22
CO_2				·00	5·56	4·15	·17	3·29	·00	·00
					FeS_2 ·05					
Total	99·99	100·16	100·12		100·41	99·97	100·48			
Dried* at 100° C.	6·43	3·55	8·49		9·98	5·46	9·08			
Ignited†	11·63	20·48	12·70		8·24	6·48	5·04			

* Percentage loss of original air dried powder.
† Additional percentage loss of original powder on ignition.

The second sample is the most remarkable. Although it retains the form of the original lava, which was evidently a basalt with distinctly columnar structure, it has changed to an ochre-colored substance that seems almost light enough to float in water, and is as friable as bath brick. Its composition is remarkable, and especially instructive if it should prove, as is probable, that this rock has been subject to the prolonged action of sea water. It consists mostly of alumina and ferric oxide, with nearly nine per cent of titanic acid and only half that quantity of silica.

The tufas consist essentially of fragments of lava more or less changed by weathering, so that the color is generally of a rusty brown, sometimes mottled with white or with various colors according to the nature of the included particles. Small crystals, or fragments of crystals, of chrysolite are often to be

seen; occasionally there are masses, two to eight centimeters or more, in diameter of such crystals, and similar aggregations sometimes of augite crystals. [These aggregations of crystals are found, I believe, only in the tufa from the Salt Lake region.] The fissures through which the materials of these tufas were ejected, opened through the coral reef formation, and so the tufa contains fragments of the coral rocks from the size of a pin's head to that of a goose egg. The mingled steam and carbonic acid forced up through the magma from which the tufa consolidated, dissolved much of the lime of this coral rock, depositing it again, partly in finely divided state mingled with the mud in its superficial portions, chiefly in crusts on the surface, or in veins occupying fissures in the already consolidated rock. In the tufa of Punchbowl, No, 1, this calcium carbonate has assumed a crystalline form, not only in the joints of the tufa, but penetrating its substance throughout. The regular calcite cleavage planes can be distinctly seen on surfaces of fracture, although the calcium carbonate amounts to no more than five to ten per cent of the rock.

TABLE IV. COMPARISONS.

	Sound Lava. Av.	Tufa. Av.	"Rotten" Lava. Av.	Soil. Av.	Punahou Rock.	Punahou Soil.
SiO_2	1680	·1393	320	800§	1201	811§
TiO_2	128		110		97	
Al_2O_3 } *	1000	1000	1000	1000	1000	1000
Fe_2O_3 }						
FeO†	(156)	(37)	(35)	not estim.		
MnO	18	10	5	4	13	5
CaO	303	352‡		22	404	118
MgO	213	358	9	20	324	71
Na_2O	148	66	7	(9)‖	208	(24)‖
K_2O	37	30		(8)‖	63	(15)‖
CuO	7	3	5	not estim.	8	not estim.
P_2O_5	23	23	6	12¶	37	49
SO_3	4	4	6	4	9	4

* The Fe_2O_3 includes total iron present.

† Representing ferrous iron.

‡ If the calcium present as carbonate (coral reef rock) be deducted, this figure would be about 338.

§ Insoluble residue, almost wholly SiO_2 and TiO_2.

‖ Na_2O and K_2O dissolved by boiling hydrochloric acid; the soil generally contains a much larger amount, in the form of insoluble silicates.

¶ In soils found from lapilli, the phosphoric acid is generally at least as high as in the lapilli, illustrated in the Punahou soil in the table.

Table IV sums up the conclusions to be drawn from these analyses. Since the alumina and iron together constitute a tolerably constant factor in the composition of the lava, and are not liable to be dissolved out in appreciable quantity within

the time covered by the history of these rocks, I have made these jointly a basis of comparison, to bring out the nature of the changes that have taken place in the weathering of the lava and its conversion into soil. While generalizations cannot be based too confidently on the results of so small a number of analyses, I believe that the data are sufficient to yield us some quite definite and positive conclusions. The validity of the general conclusions is confirmed by the specific example given in the last two columns, where analysis has been made of the identical rock from which the sample of soil has been derived.

We see then that, in the incipient weathering of lava that we find in volcanic tufa (which consists of lava fragments *plus* calcium and magnesium carbonates, and some clay and sea sand), that there has been a notable reduction of silica (17 per cent), titanic acid (practically all), manganese (44 per cent), soda (55 per cent), potash (19 per cent), copper (60 per cent), while calcium remains unchanged and magnesium seems actually to have been increased. [This may have come from the sea water.] There has been, moreover, an oxidation of three-fourths of the ferrous iron.

In the "rotted" lava, there has been a loss of more than 80 per cent of the silica, while titanic acid has been but slightly reduced. [If we omit from the comparison sample No. 2 of the rotted lavas of Table III, the loss of silica would be less considerable, that of titanic acid greater.] There has been a loss of manganese (72 per cent), magnesia (96 per cent), soda (95 per cent), copper (30 per cent), and phosphoric acid (74 per cent), while lime and potash have almost wholly disappeared. Sulphates, on the other hand, appear to have increased, but possibly this would not prove generally true.

In the soil, we find a loss of more than half the silica, 77 per cent of the manganese, 93 per cent of the lime, 91 per cent of the magnesia, and about 50 per cent of the phosphoric acid. Sodium and potassium are largely diminished, but not to the extent indicated in the table, since these bases are only partially extracted by hydrochloric acid. In soils like that of Punahou, formed from lapilli in which the original material is as yet only partially disintegrated, there may be an actual increase in the proportion of phosphoric acid. In the Punahou soil the reduction of silica amounts to only 32 per cent, of manganese to 61 per cent, lime to 72 per cent, magnesia to 78 per cent and sulphuric acid to 55 per cent.

It is especially interesting to note that while the rotted lava has lost positively nearly all its calcium and potassium, the soil retains a considerable proportion of both these elements, a result to be attributed, in part at least, to the influence of plants and, in the case of calcium, of molluscous animals.

Art. LXI.—*The Original Trenton Rocks;* by Theodore G. White.

["The Faunas of the Upper Ordovician Strata at Trenton Falls, Oneida Co., N. Y." Trans. N. Y. Acad. Sci., xv, 71-96, Pls. II—V.—Author's abstract.]

This study is preliminary to a paper by the writer on the Trenton formation in the Lake Champlain valley, in connection with which it was desirable to have a detailed description of the type Trenton Falls section for comparison. As no such tabulation had been published, nor even a statement of the local geological boundaries of the original section, the writer was obliged to go into the field for himself and the results embraced in this paper were obtained.

The type section extends from the bridge just below the mill dam at Trenton Falls village to the bridge at Prospect, about two and a quarter miles along the gorge of West Canada creek. In this distance the creek makes a total fall of over 312 feet. The dip of the strata is in the direction of the current and averages less than 10°. Both above and below the gorge in which the type section occurs, the strata are obscured by heavy drift deposits, so that the beds adjacent to those outcropping in the gorge cannot be determined. Utica shale is not found nearer than Nine Mile Creek, East Trenton, where it is apparently faulted against the Trenton. The shaly layers which form the transition to the Utica in other localities are not represented, but presumably follow the coarse crystalline limestone at the top of the gorge. The 325 feet of strata embraced in the Trenton Falls section seem to include the middle and the beginning of the upper part of the series of strata comprised in the Trenton formation. They apparently indicate a prolonged period during which there were frequent oscillations of the land level, and consequently variable deposition, the waters at first rendered impure by silts but finally clearing and furnishing large accumulations of purely fragmentary remains. In general the lower part of the formation, as seen in the type section, is mostly shaly and is inclined to be nodular, but the limestone increases in purity and becomes crystalline in the higher layers. With the exception of the gray crystalline beds at the top of the mass, the layers rarely exceed one foot in thickness, and are usually two to six inches thick, separated by more shaly layers. There are, however, occasional conspicuous seams of compact blue-black limestone, several feet thick, which continue very constant and hence afford excellent datum levels in measuring the section. From these heavy beds the best specimens of *Asaphus* are obtained,

usually found lying with the ventral surface uppermost. Each layer was separately measured and liberally sampled, and the successive faunal lists, measurements, and descriptions of the lithologic variations of the limestone are enumerated in the paper. The total thickness of the Trenton Falls section thus obtained is 325 feet. Of this, the upper twenty feet consists of heavy-bedded, light gray, coarsely crystalline limestone, very pure, and composed of comminuted fragments in which few species can be recognized. The beds are separated by slightly bituminous thin shaly partings, like the similar strata near Montreal, Canada, and these contain numerous remains, especially crinoids and *Acidaspis Trentonensis*,—the latter not seen lower in the mass.

The lower strata of the Trenton formation are not seen at Trenton Falls, and following down stream, no outcrop of any considerable thickness is found until Rathbone Brook is reached, 3½ miles below Poland, where a section of over 137 feet is afforded in the bed of the brook. Here the limestone is thin-bedded but shows more distinctly marked zones than at Trenton Falls; is light colored, and frequently sandy in texture. A short distance north of where the brook enters West Canada Creek, an outcrop on the edge of the creek yields a section of Calciferous, Birdseye and Black River, respectively 8, 9½ and 11¾ feet in thickness. The Chazy is lacking, apparently through non-deposition. The Black River is barren at the base, but above contains abundant *Illænus crassicauda*, *Leperditia fabulites*, *Avicula trentonensis*, *Raphistoma americana*, *Cypricardites obtusus* and *C. ventricosus*, *Zygospira recurvirostra*, *Strophomena filitexta*, *Rhynchotrema inæquivalvis*, *Bathyurus extans*, *Cyrtoceras tenuistriatus*, etc., twenty-six species being noted in all.

In both sections of the Trenton, the fossiliferous portions tend to occur in lenticles, sometimes composed entirely of fragments of one or two species. *Orthis testudinaria*, always abundant, frequently occurs in this way. The transition between the light-colored fossiliferous lenticles and the dark compact limestones is often very abruptly marked, the lenticles evidently resulting from depressions filled with fragments in an otherwise even surface of the finest carbonaceous lime sediments. Several well characterized zones occur, but specialized faunal zones are not frequent. In the Rathbone Brook series *Prasopora* of a large tubed variety and *Stenopora fibrosum* are especially abundant in the lower 30 feet. *Holopea symmetrica* and *Trematis terminalis* are rather abundant at from 15 to 30 feet above the base of the section. *Conularia trentonensis* is first found at 30 to 50 feet. *Parastrophia hemiplicata*, which occurs just above the top of the Black River at

Watertown, N. Y., and on Lake Champlain, was found here at about 55 feet. In the Trenton Falls section *Orthoceras* and Crinoid fragments are most abundant in the lower portion. *Tellinomya dubia* marks a zone at 18 feet, *Bucania punctifrons* at 40 feet, while at 235 feet is a zone notable for its numerous well-preserved examples of *Rafinesquina deltoidea*. A limestone resembling a cement rock, with graptolites, *Conularia* and *Ambonychia bellistriata*, occurs at 139 feet. Seventy-nine species are recorded in all in the faunal lists of the various beds. *Platystrophia biforata*, *Rafinesquina alternata*, *Plectambonites sericea*, *Asaphus platycephalus*, *Calymene senaria*, and *Ceraurus pleurexanthemus* are prevalent throughout the section. *Rhynchotrema inæquivalvis*, *Bellerophon bilobatus*, *Nucula levata*, *Murchisonia gracilis*, and *M. milleri*, and *Trinucleus concentricus* occur principally in the lower layers. In the more shaly layers, various species of *Lingula* occur throughout, and one apparently new species was discovered. *Trematis* seems to be confined to the lower strata, while *Crania trentonensis* first appears toward the top. Various typical Trenton species of frequent occurrence in other localities, such as *Climacograptus*, *Solenopora compacta*, *Orthis occidentalis*, *O. tricenaria*, *O. subquadrata*, *Leptæna rhomboidalis*, *Rhynchotrema capax*, *Cyclospira bisulcata*, were not found among the material collected, indicating that they are at least not abundant, if indeed they occur in the region.

The relative position in the stratigraphy of all the genera previously mentioned has been found in general to be similar in the Lake Champlain valley, and the species lacking at Trenton Falls are lacking there also, apparently indicating comparatively uniform life distribution around the Adirondack island during the period of Trenton seas.

Geological Department, Columbia University.

Art. LXII.—*The Jurassic Formation on the Atlantic Coast;** by O. C. Marsh.

The absence of all Jurassic strata in the eastern part of the United States has been generally regarded as a settled point in geology for half a century or more. The reason for this vacancy has also been one of the problems geologists have had to deal with, since the formations above and below are well represented. Until a comparatively modern date, this supposed absence of Jurassic deposits was thought to be true, also, for the rest of this country. I well remember the parting advice given me by an eminent professor of geology with whom I studied in Germany.† "The first thing you should do on your return to America is,—look for the Jurassic formation. I am sure it is there, full of fossils." This advice I followed, and on my first visit to the Rocky Mountains, in 1868, I found this formation near Lake Como, Wyoming, well developed, and containing an abundance of typical fossils. As this locality is now a famous one, I have brought here a colored drawing that shows the characteristic variegated strata of the Como Bluff, from which so many remains of Jurassic vertebrates have been taken during my long explorations there.

The base of this section is a red sandstone, apparently of Triassic age. Next above are Jurassic marine beds, with many invertebrate fossils and a few remains of reptiles. Over these beds is a series of peculiar, highly colored clays of fresh-water origin and considerable thickness, rich in vertebrate fossils. Crowning all is the characteristic Dakota sandstone, generally considered of Cretaceous age. The position of this series of strata in the geological scale is shown in the section below, which represents especially the succession of vertebrate life in the West during Mesozoic and Cenozoic time.

The Baptanodon Beds.

The same marine beds that constitute the base of the Como Jurassic series, Meek had previously identified near the Black Hills, by means of invertebrate fossils (Proc. Acad. Nat. Sci., Phila., vol. x, pp. 41–59, 1859). I found these deposits again in 1870, near the Green River in Utah, and since then at various other points. These strata I have named the Baptanodon beds, from a genus of large swimming reptiles entombed in them.

* Abstract of Communication made to the National Academy of Sciences, New York meeting, November 18, 1896.

† Ferdinand Roemer, whose researches here had already added much to our knowledge of the geology and paleontology of this country.

The Atlantosaurus Beds.

The extensive fresh-water deposits of Jurassic age, that lie over the marine strata at Como, I have called the Atlantosaurus beds, from a gigantic Dinosaur especially characteristic of the horizon. Other Dinosaurs, large and small, and a great number and variety of vertebrate fossils,—mammals, birds, reptiles,

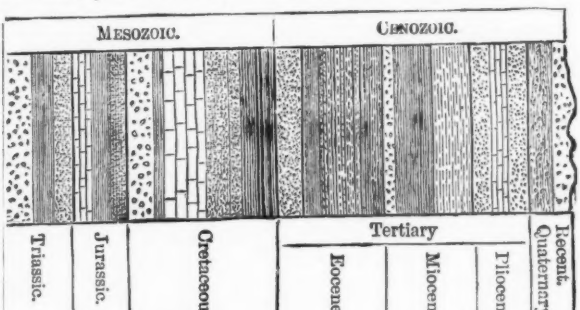

MESOZOIC.
CENOZOIC.
Recent.
Quaternary.
Tertiary
Pliocene.
Miocene.
Eocene.
Cretaceous.
Jurassic.
Triassic.
Equus Beds.
Pliohippus Beds.
Miohippus Beds.
Oreodon Beds.
Brontotherium Beds
Diplacodon Beds.
Dinoceras Beds.
Heliobatis Beds.
Coryphodon Beds.
Ceratops Beds of Laramie Series.
Fox Hills Group.
Colorado Series, or Pteranodon Beds.
Dakota Group.
Atlantosaurus Beds.
Baptanodon Beds.
Hallopus Beds.
Otozoum, or Conn. River, Beds.
Tapir, Peccary, Bison.
Bos, Equus, Tapirus, Dicotyles, Megatherium, Mylodon.
Equus, Tapirus, Elephas.
Pliohippus, Teleoceras, Hyracotherium, Procamelus, Aceratotherium, Leidy, Arctotherium, Platygonus.
Miohippus, Diceratherium, Thinohyus, Protoceras.
Oreodon, Eporeodon, Dyseonodon, Merycoidodon, Leptauchenia.
Hyracodon, Agriochærus, Colodon, Leptochærus.
Brontotherium, Brontops, Allops, Titanops, Titanotherium, Mesohippus, Limnohyus, Eotitanops.
Diplacodon, Epihippus, Amynodon, Lemuravus.
Dinoceras, Tinoceras, Uintatherium, Prionodon, Orohippus, Eohyracodon, Colonoceras, Homacodon.
Heliobatis, Anida, Lepidosteus, Asineops, Clupea.
Coryphodon, Eobasileus, Hyracops, Pantolambda, Lemuravus, Eudaemonema, Tillodontia, Rodentia, Serpentes.
Ceratops, Triceratops, Cionodon, Ornithomimus, Mammalia, Dryptosaurus, Deltheridium, Stylacodon, Nanomyops, Stagodon, Birds, Ichthyopterygia.
Birds with Teeth, Hesperornis, Ichthyornis, Apatornis, Mosasaurs, Elasmosaurus, Liodesmosaurus, Tylosaurus, Pterodactyla, Pteranodon, Plesiosaurs, Turtles.
Dinosaurs, Brontosaurus, Morosaurus, Diplodocus, Stegosaurus, Camptosaurus, Cetiosaurus, Cetiosauroides, Mammalia, Dryptodetes, Stylacodon, Tinodon, Ctenacodon.
First Mammals, Dromatherium, First Dinosaurs, Anchisaurus, Amphisaurus, Bathygenitalia, Clepsysaurus, Mammal-like Reptiles, Crocodiles, Fishes, Coleopterus, Ichthyopterus, Dolichosoma.

FIGURE 1.—GEOLOGICAL HORIZONS OF VERTEBRATE FOSSILS.

and fishes, I have likewise secured from this locality and at several other points in the same horizon, chiefly in Wyoming and Colorado. Among these extinct forms, the gigantic *Sauropoda*, the largest of all land animals, are the most wonderful, and are known only from the Jurassic. They are therefore of special value as evidence of geological age.

The main physical features of the Jurassic strata in the West, especially the variegated fresh-water deposits, are so striking that, once seen, they will not soon be forgotten. As these physical characters may be used as one means of readily identifying this horizon, I have brought here, besides the colored drawing of the Como section in Wyoming, two others illustrating sections in Colorado. One is from Morrison, near Denver, and the other one hundred miles further south, near Cañon City, both representing, in the Atlantosaurus beds, localities famous for the vertebrate fossils they have furnished. I know of no other geological horizon in the West marked by such striking and characteristic physical features.

The Pleurocœlus Beds.

In the East, the strata most resembling the Atlantosaurus beds in physical characters are the Potomac clays and sands so conspicuous between Washington and Baltimore, and known to extend, also, both to the north and south. Although fifteen hundred miles to the eastward, these Maryland strata so strongly recalled those I had explored at the base of the Rocky Mountains, I felt reasonably sure, even before I had examined them, that this series would turn out to be essentially the same age as the Atlantosaurus beds of the West. This proved to be the case. Although the Potomac beds have been generally regarded as Cretaceous, I can now safely say that the vertebrate fossils I have secured from them, especially the *Sauropoda*, demonstrate their Jurassic age beyond reasonable doubt. I stated this conclusion in my first description of Potomac fossils, and it is now fully confirmed by more recent discoveries.*

The fact that the *Sauropoda* of the Potomac beds are all of diminutive size, in comparison with the western forms, is a point of some importance in estimating the age of the strata that contain them. It is a rule almost without exception, that the earlier members of an order of ancient vertebrate animals are small, while the last survivors before extinction are the largest. The gigantic forms of every such group left no successors. Hence, the small *Pleurocœlidæ* of the East may possibly be the ancestors of the huge western *Atlantosauridæ*, but can hardly be their descendants. The other vertebrate fossils from the Potomac of Maryland, although fragmentary, all appear to be Jurassic in type.

* This Journal, vol. xxxv, p. 90, 1888. See also, Sixteenth Annual Report, U. S. Geol. Survey, Part I, p. 183, 1896.

It cannot, of course, be positively asserted at present that the entire series now known as Potomac is all Jurassic, or represents the whole Jurassic. The Lias appears to be wanting, and some of the upper strata may possibly prove to belong to the Dakota. The latter formation in the West often lies apparently conformably on the Atlantosaurus beds, and besides its many fossil plants contains fragments of bones, but these may have washed out of the Jurassic clays below. Footprints resembling those of birds have also been found.

The Potomac Formation.

The Maryland Potomac, as we know it to-day, is the keystone to the arch. If this is Jurassic, as now seems certain, it is a fair conclusion that the same series of deposits, north and south, are essentially of the same age. The only region along this line of a thousand miles or more, where a systematic search for vertebrate fossils has been made, is in Maryland, and here a rich fauna has been found. Doubtless in many outcrops of this formation, animal remains may be rare or absent, as they appear to be in the Triassic below, but vertebrate life we know was abundant during the Jurassic, and characteristic remains will sooner or later come to light.

Taking, then, the Potomac formation as it is developed in Maryland as an eastern representative of the Jurassic, let us see what follows. The authorities on this formation—McGee, Ward, Fontaine, Uhler, and others, agree that it extends south along the Atlantic border as far as North Carolina, holding the same relative position, and the same general characteristics. That it also extends west around the Gulf border has been asserted by those most familiar with its southern development, but on this point I cannot speak from personal observation.

From the Potomac River northward, however, I have made sufficient explorations along its outcrops through Maryland, Delaware, and Pennsylvania, to the Delaware River, to ascertain its distinctive features, essentially the same throughout, with its geological position still maintained. In New Jersey, I have likewise followed its equivalent strata across the state in the great series of variegated plastic clays, to the Raritan River, and again in their exposure on Staten Island, everywhere seemingly the same series of strata and of the same age. The position is a definite one, always along the line where the Jurassic must lie, if present.

Along the northern shore of Long Island, the same formation extends, and at many outcrops it may be seen with its characteristic features well displayed. I have recently examined these exposures at many points, and all tell the same story. At Montauk Point and on Gardiner's Island, I found apparently the same deposits, but with local variations that need not now be discussed.

Block Island, evidently once a part of Long Island, I have also examined. Its basal clays agree in most respects with the above representatives of the same horizon, as I have shown elsewhere.*

Gay Head.

By far the finest exhibition of the great formation in question may be seen on Martha's Vineyard, especially at Gay Head, which for a century has attracted the attention of geologists, who have tried in vain to solve its mysteries. My first visit to this classic region was in September last, and I know of no point on the Atlantic coast, from Nova Scotia to Florida, of more interest to geologists. The striking resemblance between the variegated cliffs at Gay Head, the Potomac hills in Maryland, and Como bluffs in Wyoming, will impress everyone who has seen them. That all three are of essentially the same geological age, I have good reason to believe. Two of them are certainly Jurassic, as demonstrated by typical vertebrate fossils, and I hope soon to prove that Gay Head, so similar in all other respects, also contains the same characteristic vertebrate fauna that marks the Jurassic,—the long missing formation on the Atlantic coast.

It has already been shown that the vertebrate fossils of the Potomac in Maryland prove its age there to be Jurassic, especially when taken in connection with the rich fauna of the Atlantosaurus beds of the West. In determining the age of the whole series, every aid that paleontology can render should be brought to bear upon the question, but a discrimination greater than has hitherto been shown is necessary to secure the best results. .

In addition, then, to the evidence of vertebrate fossils as to the age of this eastern formation, the testimony of the invertebrates and plants should also be considered. The invertebrates known from these strata are few in number, but some of the mollusks among them point to the Jurassic age, as Whitfield has shown.† Nearly all, however, were estuary or fresh-water forms, which are now generally admitted to be of slight value as witnesses of geological changes.

Evidence of Fossil Plants.

Remains of plants are numerous, but usually fragmentary, and these have been collected at many localities, and studied by botanists of much experience in such investigations. The verdict they have rendered has not been a unanimous one, but is especially interesting, as it coincides at one point with the decisions some of their predecessors have rendered as to the age of other geological horizons in the succeeding formations of the West.

* This Journal, vol. ii, p. 295, October, and p. 375, November, 1896. In the second paper will be found an abstract of the more important literature.

† Monograph IX, U. S. Geol. Survey, p. 23, 1885.

The horizons I especially refer to are in the Dakota, Laramie, and Eocene, all essentially of lacustrine origin, and now well known. Fossil plants in good preservation have been collected in each of these in turn, and pronounced by eminent botanists to be Miocene. Other paleobotanists of equal eminence have reviewed the evidence and made the age somewhat older, but, as a rule, the conclusion reached made the deposits in question at least one period later than the animal remains indicated. To explain this discordance, it was in one case gravely asserted that a Cretaceous vertebrate fauna lived in the midst of a Tertiary flora. A larger knowledge of the facts has since led to revision of the first opinions on this point, and the Cretaceous age of both is now admitted.

It seems to me extremely probable that in the Potomac formation we again have an analogous case. The botanists have pronounced the plants Cretaceous, while the vertebrates are certainly Jurassic. Change the botanical scale one notch, as was done in the horizons above, and the flora and fauna agree, while the Jurassic formation, so long missing, is in its proper place on the Atlantic coast as it is in the West. The North American botanical timepiece was originally set by the European clock, which was one period too slow, as many facts now indicate. Sooner or later, an adjustment must be made.

Age of the Wealden.

To illustrate this, I may mention, as the latest change in the European time-standard, the Wealden formation, the Cretaceous age of which has long been considered a settled point. I had studied this formation at many localities in England and on the continent, as it contained a reptilian fauna similar to one I had found in the Rocky Mountains, and regarded as Jurassic. A further study of the Wealden reptiles caused me to question their Cretaceous age, and a comparison of these with allied forms from the Rocky Mountains led me to the conclusion that both series were Jurassic.

At the meeting of the British Association, at Ipswich, last year, I read a paper on European Dinosaurs, including two from the Wealden, and thus the question of their geological age came up for determination. The facts I presented, based mainly upon the reptilian fauna, strongly indicated the Jurassic age of the Wealden, and I urged a re-examination of the question by English geologists.* The subject has since been taken up by Smith Woodward, with special reference to the fossil fishes, on which he is high authority. In the Geological Magazine for February, 1896, he gives the main results of his investigation, which prove that the fishes, also, of the Wealden are of Jurassic types, thus placing the geological age of this formation beyond reasonable doubt.

* Report, British Association for the Advancement of Science, p. 688, 1895; and this Journal, vol. l, p. 412, November, 1895.

The same conclusion, based upon a review of the Wealden plants, has recently been reached by A. C. Seward, likewise an eminent authority, who states the case as follows: "The evidence of paleobotany certainly favors the inclusion of the Wealden rocks in the Jurassic series." *

Age of the Laramie.

The problem before us to-day has a strong family resemblance to another with which geologists were face to face twenty years ago; namely, the geological age of the great lignite series of the West. Then as now, the plants and the animal remains seemed to tell a different story, and I was thus led to investigate the question with considerable care. It may perhaps aid in solving the present problem if I repeat what I then said so far as it relates to the value of different kinds of fossils as evidence of geological age. In an address before the American Association for the Advancement of Science, in 1877,† I stated the case as follows:

"The boundary line between the Cretaceous and Tertiary in the region of the Rocky Mountains has been much in dispute during the last few years, mainly in consequence of the uncertain geological bearings of the fossil plants found near this horizon. The accompanying invertebrate fossils have thrown little light on the question, which is essentially whether the great Lignite series of the West is uppermost Cretaceous or lowest Eocene. The evidence of the numerous vertebrate remains is, in my judgment, decisive, and in favor of the former view.

Relative Importance of Fossils.

"This brings up an important point in paleontology, one to which my attention was drawn several years since; namely, the comparative value of different groups of fossils in marking geological time. In examining the subject with some care, I found that, for this purpose, plants, as their nature indicates, are most unsatisfactory witnesses; that invertebrate animals are much better; and that vertebrates afford the most reliable evidence of climatic and other geological changes. The subdivisions of the latter group, moreover, and in fact all forms of animal life, are of value in this respect, mainly according to the perfection of their organization or zoological rank. Fishes, for example, are but slightly affected by changes that would destroy reptiles or birds, and the higher mammals succumb under influences that the lower forms pass through in safety. The more special applications of this general law, and its value in geology, will readily suggest themselves."

* Catalogue British Museum, Wealden Flora, p. 290, 1895.
† This Journal, vol. xiv, p. 338–378, November, 1877.

In the statement I have quoted, I had no intention of reflecting in the slightest degree on the work of the conscientious paleobotanists who had endeavored to solve the problem with the best means at their command. I merely meant to suggest that the means then at their command were not adequate to the solution.

It so happened that the most renowned of European botanists, Sir Joseph Hooker, was then in this country, and to him I personally submitted the question as to the value of fossil plants as witnesses in determining the geological age of formations. The answer he made fully confirmed the conclusions I had stated in my address. Quoting from that, in his annual address as president of the Royal Society, he added his own views on the same question.* His words of caution should be borne in mind by all who use fossil plants in determining questions of geological age, and they are especially applicable to the problem now before us,—the age of the Potomac formation.

The scientific investigation of fossil plants is an important branch of botany, however fragmentary the specimens may be. To attempt to make out the age of formations by the use of such material is too often labor lost and must necessarily be so. As a faithful pupil of Goeppert, one of the fathers of fossil botany, I may perhaps be allowed to say this, especially as it was from his instruction that I first learned to doubt the value of fossil plants as indices of the past history of the world. Such specimens may indeed aid in marking the continuity of a particular stratum or horizon, but without the reinforcement of higher forms of life can do little to determine the age.

The paleobotanists have certainly failed repeatedly in the past, in attempting to define geological horizons by fossil plants alone. Although they have this record as a guide, some of them are still using the same methods, the same material, with the same confidence, that formerly misled their predecessors. In view of this, and of the great importance of the present question, is it too much to ask them to reconsider their verdict as to the age of the Potomac formation?

Were the fossil plants of the Potomac that have been pronounced Cretaceous unknown, the Jurassic age of this extensive series would have been accepted as a matter of course long ago. The strata themselves lie exactly in the position the Jurassic should occupy. They agree in physical characters more closely with the shallow fresh-water shales and sandstones of the Trias below, than with the deep-sea Cretaceous beds above. Still more important, the animal remains taken together, invertebrates and vertebrates, indicate one fauna, the Jurassic. Under these circumstances, the plants alone cannot finally decide the age.

* Proceedings Royal Society of London, vol. xxvi, pp. 441, 443, 1877.

Position of Jurassic Strata.

In the geological section, figure 1, on page 434, the relative position of the Jurassic deposits of the West is designated, and this will hold good for all the strata of that age in known localities on both flanks of the Rocky Mountains. In the East, the position of the deposits here regarded as Jurassic is equally definite, and corresponds strictly to that of the western horizon in its most essential features. A reference to the section in figure 2, below, will make this clear. This typical section is based on one by G. H. Cook, in the Geology of New Jersey,* and represents the successive Mesozoic and more recent formations, from New Brunswick, New Jersey, on a line southeast, through Lower Squankum to the Atlantic. The relative proportions and inclination of the various divisions cannot, of course, be given accurately in so small a figure. The distance represented by this section is about forty miles.

2.

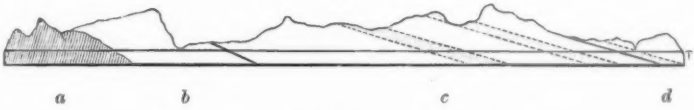


FIGURE 2.—Geological Section in New Jersey.

a, Triassic; *b*, Jurassic; *c*, Cretaceous; *d*, Tertiary; T, tide level.

In this section, the red Triassic shales and sandstones are shown on the left, highly inclined. Resting on their eroded surface are the well-known variegated plastic clays, also of fresh-water origin. These strata are nearly horizontal, having a slight inclination toward the ocean. The top of these peculiar clay beds is not clearly defined, but is marked by a change from lacustrine to marine conditions, which clearly indicate deposition in water of increasing depth, and finally deep-sea glauconite strata. These greensand deposits continued with some interruptions throughout the remaining Cretaceous time, and even into the early Tertiary, the third, or upper, marl bed being Eocene. Over these are strata of Miocene age, the Ammodon beds, and still more modern deposits form the shore of the Atlantic.

Atlantic Barriers.

The change from the fresh-water plastic clays of New Jersey to the marine beds containing greensand over them proves not only the breaking down of the eastern barrier which protected the former strata from the Atlantic, but a great subsidence also, since glauconite, as a rule, is only deposited in the deep, still waters of the ocean.

* Geological Map, Cretaceous Section 3, 1868.

The Miocene greensand surmounting the Gay Head clay cliffs on Martha's Vineyard also means the same thing, and a still greater lapse of time, as the whole Cretaceous and Eocene strata are here apparently absent. The present height of these Miocene strata indicates indirectly the minimum of elevation, the depth of the sea in which they were deposited being at present one of the unknown elements. It has been suggested by some geologists that the eastern barrier was composed of granitic rocks, and thus furnished the materials for the New Jersey and other clays.* Many known facts support this view.

The western, or inner, barrier of this great fresh-water border lake is still well marked. In the New England region, the present rock-bound coast line indicates its approximate position, and retains in its bays and inlets remnants of the deposits then laid down. Away from the coast, I know of only a single locality that seems to have preserved these beds, and that is near Brandon, Vermont. This basin I explored long ago, and if my memory serves me rightly, I saw there the typical clays, lignites, and iron ores, that mark the horizon now under consideration. South of New England, the inner barrier is equally well defined by the Triassic and older rocks to the Potomac River, but beyond that point I have not carefully examined it.

Physical Characters of the Jurassic.

The strong resemblance in their physical characters between the fresh-water deposits here regarded as Jurassic and those long known to be such in the Rocky Mountain region is largely dependent on the materials of which they are formed, and the conditions under which they were deposited. The close correspondence in this respect between the beds of the two regions should have some value in estimating their age.

The most striking feature in these deposits is the variety of colors in the plastic clays. Brilliant red, green, and yellow tints are especially prominent, yet the white and black shades are equally noticeable. While these colors are often seen in great masses, marking definite strata in fresh exposures, they blend one with another from the effects of weathering, where the original colors wash over each other. In the Rocky Mountain region, the brilliant hues of the Jurassic strata may be seen for miles on the face of the high bluffs. This is especially remarkable in the cliffs at Como, Wyoming, a representation of which is before you. Still more brilliant effects may be seen in the canyons on the west side of the Green River, in Eastern Utah.

East of the Rocky Mountains, the same color scheme is well illustrated around the Black Hills, in South Dakota. Again in the foot-hills west of Denver, near Morrison, Colorado, a

* Geology of New Jersey, Report on Clays, p. 30, 1878.

similar exhibition is to be seen, as represented in the second drawing. This is repeated on a much larger scale further south, near Cañon City, Colorado, as likewise shown in still another sketch, but none of these colored drawings does justice to the natural scenery.

On the Atlantic coast, the same combination of colors, although less brilliant, may be seen in the Potomac outcrops in Maryland, now proved by vertebrate fossils to be likewise Jurassic. Further north, the reds predominate in this horizon across Delaware and Pennsylvania, but in the plastic clays of New Jersey, the strong distinct colors, usually in horizontal bands, are dominant. On Staten Island and at various outcrops along the northern shore of Long Island, as well as on Block Island, the same horizon is distinctly marked by variegated patches, while still further east, at Gay Head, on Martha's Vineyard, the most startling color display of the whole Atlantic coast forms a flaming beacon that mariners and geologists alike have for a century held in high esteem. I know of no other horizon of equal extent so readily distinguished from all others by its physical features.

Early Investigations.

In the early days of American geology, the pioneers here, as in other branches of science, attempted to refer everything to European standards. In this way, strata of various ages, as we now know, were called by European names, and were supposed to represent equivalents. In this general way, the terms Lias, Oolite, etc., were applied to strata on the Atlantic coast. It was soon found, however, by the actual workers in the field, that our geological sequence had only a general correspondence with that of Europe or of other parts of the world, yet some geologists still endeavor to harmonize the time tables, but with only moderate success. It is, however, now becoming known, that this continent had its own law of development, and that its fauna and flora must be studied by themselves to disclose their full significance. The time ratios of America certainly do not coincide with those of Europe. The long periods of Mesozoic time represented in Europe by great deposition of many series of strata were marked here by other means as well. The rich fauna and flora that then lived here do not have their exact counterparts elsewhere.

The apparent absence on the Atlantic coast of the Jurassic as known in Europe naturally led the early geologists to seek its equivalent strata. The first supposed identification seems to have been recorded by W. B. Rogers, who called the eastern Virginia coal beds Oolitic.* These beds are now regarded as Triassic.

* Transactions Association American Geologists and Naturalists, vol. i, p. 300, 1843.

This eminent geologist also referred to the Jurassic certain silicious, argillaceous, and pebbly beds in Virginia and further north, as possibly "a passage-group analogous to the Wealden of British geology."* P. T. Tyson in 1860 referred the Maryland clays to the Cretaceous, and later to the Jurassic.†

Long before this, in 1835, H. D. Rogers, in his sketch of the geology of North America, clearly recognized what is here regarded as Jurassic as pertaining to one great formation. He described this as extending along the tide water plain of the Atlantic, from the Carolinas through Virginia, Maryland, Delaware, Pennsylvania, and New Jersey, and also as continuing on through Long Island to Martha's Vineyard and Nantucket. He gave it the name of "Ancient Alluvium," but included in it the plastic clay formation and part of the Gay Head deposits, the latter of which he considered Cretaceous.‡

The next noteworthy description of the Jurassic as here defined was given by J. C. Booth in his report on the Geological Survey of Delaware, 1841. He described the variegated plastic clays of that state, and gave to them the name of "Red Clay Formation," which he regarded as belonging to the Upper Secondary. The more recent publications on this Atlantic Coast formation are well known, and need not be cited here.

Among the early explorers who contributed to our knowledge of the Jurassic of the Rocky Mountains and Pacific coast region were J. Marcou, in New Mexico, 1853; C. King, in California, 1863; and, in the same state, W. Gabb, 1864, and F. B. Meek, 1865.

The earliest discovery of the Jurassic in the Arctic region of this country was by Sir E. Belcher, in 1852, who found remains of *Ichthyosaurus* on Exmouth Island. The latest information in regard to the Jurassic comes also from the Arctic region, where Nansen has found this formation containing many fossils, near Franz Joseph Land.

Jura-Trias.

The term Jura-Trias now in use is in reality a confession of ignorance, excusable, perhaps, a quarter of a century ago, but unpardonable now in those whose duty it is to map or define the formations of this country. Yet this term is still sometimes used for so clean-cut a Triassic horizon as the Connecticut River sandstone. It is true that in early days of New England geology, this formation was in part referred to the Jurassic, but at the present time no one at all familiar with the evidence of the abundant vertebrate life found in it could make such a mistake. This is equally true of the southern extension of the same formation along the Atlantic coast, where it is everywhere quite distinct from the Jurassic. In the West, the dividing line is less marked in some regions, but I believe that even there careful explorations alone are required to separate these two allied formations.

* Proceedings Boston Society, vol. xviii, pp. 104, 105, 1875.
† 1st Report State Chemist, Maryland, p. 41, 1860; 2d Report, p. 54, 1862.
‡ Report British Association, Edinburgh Meeting, pp. 1–66, 1835.

Vertebrate Fauna of the Jurassic.

The Jurassic age of the Atlantosaurus beds of the West has now been demonstrated beyond question by the presence of a rich fauna of mammals, birds, reptiles, and fishes. Among these, the *Sauropoda* were dominant, and the other Dinosaurs well represented.

In the Potomac beds of Maryland, the same Jurassic vertebrate fauna is present, as shown by the remains of five different orders of reptiles already discovered in them. Among the Dinosaurs are the *Sauropoda*, the *Theropoda*, and the *Predentata*, the first group represented by several genera and a great number of individuals. One of these genera is *Pleurocœlus*, which has also been found in the Jurassic of the West. Besides the Dinosaurs, characteristic remains of *Crocodilia* and *Testudinata* are not uncommon, and various Fishes have been found. The remains of these six groups already known are amply sufficient to determine the age of the formation, and still more important discoveries doubtless await careful exploration.

The discovery of vertebrate fossils further east is merely a question of systematic work. That they are there, all experience in this horizon clearly indicates. In 1870, I passed over miles of similar strata on the eastern flanks of the Uinta Mountains, with every man of my expedition on the lookout for fossils, prompted both by zeal for science and a special reward for the first specimen, but also on the alert for the hostile Ute Indians around us, yet not a fossil was seen. Ascending a few hundred feet, I found the sides of a narrow canyon full of fossils, vertebrate and invertebrate, all of Jurassic forms. The stratum once established, the supposed barren clays soon furnished rich localities.

The similar Potomac clays were formerly pronounced quite destitute of animal remains by geologists of eminence, but hard work disclosed their treasures. The coast east of the Hudson has an abundance of the same strata, and offers still greater rewards to explorers. The Gay Head Indians are not hostile, but will be found active assistants in the good work, while holding fast to the traditions of their ancestors as to the volcanic origin of their narrow sea-scourged home.

Long Island Sound.

It is evident that we know the remnants only of the great formation we are now discussing, for the larger part of it has long since been swept away, and much of the remainder is covered up or obscured by later deposits. The origin of this formation is a great question in itself, while its gradual destruction offers still larger problems to the geologist. One of these only I have time now to touch upon, and that has special interest for me, as day by day from my study window I look across the Sound to Long Island.

The origin of Long Island Sound was doubtless largely dependent upon the soft Jurassic clays that once filled its bed. The barrier on the north was the rock-bound New England coast essentially as it is to-day. The outer barrier, now removed or beneath the ocean, was perhaps of less durable material, and, as the coast subsided, gradually succumbed to the assaults of Atlantic waves. The great terminal moraine at the close of the glacial period proved a second barrier, and the waters from the melting ice and the larger rivers sought an outlet to the sea, both east and west, and thus a channel was formed in the soft clays and sands that the strong ocean currents gradually enlarged to its present size.

Conclusion.

The problem now before us is the presence or absence, on the Atlantic coast, of strata of Jurassic age. The exact position where such deposits should be found, if present, is well known to all geologists familiar with our eastern border. The fresh-water Triassic beds below this position and the extensive marine Cretaceous above have long ago been carefully studied, and their exact limits defined.

For many hundred miles, along the line where the Jurassic should occur, there is a well-marked series of fresh-water clays and sands quite distinct from anything else on the coast, and the question is,—are these beds of Jurassic or Cretaceous age? The prevailing opinion hitherto has been strongly in favor of the latter, although this view separated two allied fresh-water formations, and still left out the great Jura, so well represented in other parts of the world, and especially in our own Rocky Mountain region.

How difficult it is to lay aside preconceived opinions, everyone knows. The long supposed absence of the Jurassic on the Atlantic coast seems to have blinded those who had the formation under their feet. The evidence to-day in favor of its presence, if not conclusive at every point, is vastly greater than the opposing testimony. Moreover, its acceptance explains at once a mystery of long standing,—why the records of Jurassic time were not preserved here in their true place.

To call this peculiar Atlantic formation Cretaceous in its various eastern outcrops, when the western expansion of the same characteristic deposits has been proved Jurassic, is certainly not scientific. To do this in the light of present testimony, including the animal remains, vertebrate and invertebrate, the unique structure and materials of the strata themselves, and especially their definite position where the Jura should be, is to violate the laws of evidence.

No geologist familiar with the facts will deny that the variegated Potomac clays in Maryland are continuous with those in Delaware, Pennsylvania, and New Jersey, and that the similar basal clays on Long Island, and the other islands to the eastward as far as Nantucket, are part and parcel of the same series. There is now positive proof that the southern end of this series is Jurassic, and it is certainly a fair conclusion that the remainder is of the same age. The burden of proof will rest upon those who hold to the contrary.

To place the strata in question in the Jurassic section of the Atlantic coast at once removes many difficulties that have hitherto perplexed students of the Mesozoic of this region. It completes the series, and shows in part, at least, what was done in deposition during that long interval between the end of Triassic and the beginning of Cretaceous time, when the great barrier was broken down, which, from the Devonian to the Cretaceous, shut out the waters of the Atlantic.

I must leave it to others with leisure at their command to work out the details of this well-marked series, and its relation to those above and below. I have no time to devote to the surface geology of this belt or to the earlier deposits of Tertiary time. Just now, the Mesozoic interests me most of all, especially its middle section, the Jurassic, as I believe great injustice has been done, since this has been denied its rightful place, and a name not its own stamped upon it.

In a later communication, I hope to discuss this question further, and especially the Jurassic beds south of the Potomac River.

Yale University, New Haven, Conn., November 16, 1896.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *The chemistry of the Cyanide Process.*—Two views have been expressed concerning the chemical reaction which takes place in this very important, recent process for extracting gold from its ores. These are represented by the following equations:

$$2Au + 4KCN + 2H_2O = 2KAu(CN)_2 + 2KOH + H_2$$
$$4Au + 8KCN + 2H_2O + O_2 = 4KAu(CN)_2 + 4KOH$$

The second equation represents the view which is now generally accepted, and Bodlaender has recently shown conclusively that no hydrogen is evolved when gold is placed in contact with potassium cyanide solution. He placed finely divided gold and the cyanide solution in an exhausted retort, and after a contact of fourteen days no hydrogen could be detected. He showed, moreover, that the presence of oxygen was necessary for the dissolution of the gold, but he has found that the commonly accepted equation, the second one given above, does not fully represent the reaction, but that hydrogen peroxide is at first produced and that the reaction takes place in two stages, viz.,

$$2Au + 4KCN + 2H_2O + O_2 = 2KAu(CN)_2 + 2KOH + H_2O_2$$
$$2Au + 4KCN + H_2O_2 = 2KAu(CN)_2 + 2KOH$$

The author proved conclusively that hydrogen peroxide is produced in the reaction, and that its formation is more abundant the more rapidly the solution of the gold takes place. When the hydrogen peroxide was removed as fast as it was formed by having calcium hydroxide present in the solution (thus producing a precipitate of calcium peroxide), the author was able to obtain about two-thirds of the theoretical hydrogen peroxide by quantitative determination.—*Zeitschr. für angew. Chem.*, 1896, 583.

H. L. W.

2. *Beryllium not isomorphous with the metals of the magnesium group.*—The true place of beryllium in its relation to other elements has been a matter of much discussion. It is at present generally admitted that it is a bivalent element, and the isomorphism of its salts with those of the metals of the magnesium group is assumed by the authors of certain text books, although such isomorphism does not appear to have been distinctly proven. Retgers has now made a careful study of the crystallization of mixtures of beryllium sulphate and the sulphates of copper, nickel, iron and manganese, and has discussed the results of Klatzo, who used the sulphates of magnesium and zinc in the same way with beryllium sulphate, as well as the results of Marignac and of Atterberg in connection with beryllium and magnesium salts. He finds that there is no evidence of the isomorphism of beryllium with any of these metals. He believes also that the apparent

isomorphism of phenacite and willemite, as well as that of beryllium oxide and zinc oxide, and of the two metals beryllium and magnesium, may be accidental.—*Zeitschr. für physikal Chem.*, xx, 481. H. L. W.

3. *The non-existence of two Orthophalic Acids;* by H. L. Wheeler, from the advance sheets of an article to be published in the American Chemical Journal.—In the June number of this Journal of the present year, vol. i, p. 485, an article by Mr. W. T. H. Howe upon the existence of two orthophthalic acids was briefly reviewed. Dr. Wheeler now shows conclusively that no new acid can be prepared by the methods given by Howe, and it is evident that the facts upon which Howe's article was based were false, and the theoretical conclusions, interesting and important as they seemed, were without foundation. H. L. W.

4. *Humphry Davy, Poet and Philosopher;* by T. E. Thorpe, 8vo, pp. 240. New York, 1896 (Macmillan & Co., price $1.25).—This book, appearing in the "Century Science Series," has as its subject one of the most notable and interesting pioneers of chemistry. Sir Humphry Davy was perhaps the greatest of England's popular lecturers upon scientific subjects, and among his great discoveries we owe to him the first knowledge of the effects of breathing nitrous oxide, the discovery of the alkali and alkali-earth metals by the use of electrolysis, the recognition of chlorine as an elementary body, and the well-known safety lamp. Professor Thorpe has handled his subject in his usual charming style, and has made the book a fascinating one, not only to the chemist, but also to the general reader. Much material, hitherto unpublished, has been introduced. The author has not failed to give a good impression of Davy's genius, but he has also allowed us to understand his frailties and peculiarities. H. L. W.

5. *Chemistry in Daily Life;* by Lassar-Cohn. Translated by M. M. Pattison Muir, 8vo, pp. 324. Philadelphia, 1896 (J. B. Lippincott Company, price $1.75).—This series of twelve popular lectures is very well adapted to give the general reader some idea of the simplest and most important principles of chemistry, as well as a good insight into the important applications of chemistry at the present day. The wide range of subjects touched upon may be seen from the following list of a few of them: Breathing, air, ozone, maintenance of the warmth of the body, combustion, nature of flame, fats, petroleum, the elements, chemical formulæ, the atom and the molecule, distillation, the manufacture of coal-gas and by-products, incandescent gas-lights, food of plants, bases acids, and salts, food of men and animals, common salt, importance of cooking, fermentation, alcoholic beverages, vinegar, wood spirit, explosives, wool, cotton, silk, shoddy, tanning, parchment, bleaching, drying, oil painting, varnishes, inks, paper, potash, Leblanc's process, nitric acid, bleaching-powder, ammonia soda process, soap, glass, clay, pottery, photography, the X-rays, noble and base metals, ores, bimetallism, iron and steel, regenerator furnaces, zinc, electro-deposition of metals, alloys, alkaloids, antiseptics. H. L. W.

6. *Practical Methods of Organic Chemistry;* by GATTERMANN, translated by W. B. SHOBER, 8vo, pp. 330. New York, 1896 (The Macmillan Company, price $1.60).—This book, designed for students doing laboratory work in organic chemistry, has met with a cordial reception in Germany, where this branch of instruction has attained a high degree of development. It is therefore gratifying to notice the appearance of a satisfactory English translation of this valuable book. It will be an important aid to the teaching of the subject to English-speaking students and will doubtless find an extensive use in our universities. H. L. W.

7. *The Chemical Analysis of Iron;* by A. A. BLAIR, third edition, 8vo, pp. 322. Philadelphia, 1896 (J. B. Lippincott Company).—This work is the recognized authority upon the analysis of iron, steel, iron ore, slags, fuels, etc., and it is indispensable in laboratories where such analysis is practiced or taught. In the new edition many minor changes and several important additions have been made, so that it may be considered, as it purports to be, "a complete account of all the best known methods."

H. L. W.

8. *Physikalisch-chemische Propädeutik;* by H. GRIESBACH, 8vo, erste Hälfte and zweite Hälfte, 1 Lieferung, pp. 592; the last "Lieferung" is to appear soon. Leipsic, 1895–6 (Wilhelm Engelmann).—This text-book is designed to give a general view of physical and chemical science, especially from a medical standpoint. The book covers a very wide range of subjects, and these are treated in such a manner that the reader has no need of special scientific knowledge. There is much historical information and numerous biographical notes concerning scientific discoverers and investigators are given. There are also copious bibliographical references. The book is accurate and modern, and it furnishes a valuable source of information for many classes of readers. H. L. W.

9. *On methods of determining the dryness of saturated steam and the condition of steam gas;** by Prof. OSBORNE REYNOLDS. —In certain recent attempts to ascertain the proportion of steam and water in the fluid which enters a steam engine, by means of what is called the wire-drawing calorimeters, the published results show that there remains from 0 to 5 per cent by weight of water in the steam, after it has been drained by gravitation, in the same manner as the steam on which Regnault's experiments were made. This has necessarily excited great interest in steam engineering, and is naturally welcome, as it apparently brings the performance of the engines by so much nearer perfection. Although the result of these recent experiments appear to show the condition of dry saturated steam to be other than that on which Regnault's experiments were made, and from which the present steam tables have been calculated, still these tables have been used in deducing the percentage of water latent in the steam.

* Abstract received from the author of a paper read before the Manchester Literary and Philosophical Society, Nov. 3d, 1896.

Whereas, if the latent water exists, it must have existed in the steam used by Regnault, and the steam tables must also be subject to identical corrections; and, consequently, the percentage of theoretical performance of steam engines would be unchanged.

It is then pointed out, that, in the reduction of such of these results as have been published, use has been made of Regnault's determination of the specific heat at constant pressure of steam gas (0·48) in a manner which is not consistent with the theory of thermodynamics. Thus, in Rankine's notation, S_1 is the weight of steam per lb. of fluid, and H_1 the total heat per lb. from 0° C. to $T_1°$, h_1 the heat required to raise water per lb., and H_2, h_2, T_2, the corresponding values for saturated steam at the pressure after wire-drawing, and $T_s°$ the observed temperature after wire-drawing.

The notation assumed for the equation of heat, neglecting incidental losses, is

$$S_1 (H_1 - h_1) + h_1 = H_2 + 0{\cdot}48 (T_s° - T_2°) \quad . \quad . \quad . \quad . \quad 1$$

Whereas, it has been proved by Rankine that the thermodynamic expression for the total heat in superheated steam at $T_s°$ C., provided it has reached the condition of steam gas, to which the 0·48 only applies, is

$$C_1 + 0{\cdot}48 (T_s° - T_0°)$$

C_1, being a constant, depends only on the temperature of the water ($T_0°$) from which the steam is produced, the value of which from 0° C. is 606·7, approximately, as deduced by Rankine.

Using Regnault's formula for H_2, the right member of equation (1) becomes

$$606{\cdot}5 + {\cdot}305\, T_2° + 0{\cdot}48 (T_s° - T_2°)$$

while the value by the thermodynamic formula is

$$606{\cdot}7 + 0{\cdot}48\, T_s°$$

which gives as the excess of heat over that assumed

$$0{\cdot}2 + 0{\cdot}175\, T_2°$$

This excess, if T_2 were 100° C., is 17·7 thermal units, and if the initial steam pressure were 200 lbs. above the atmosphere, the latent heat being 467·5 thermal units, the percentage of water it would evaporate, at boiling point, is

$$\frac{177}{4675} = 3{\cdot}8\%$$

which is about as much as needs to be accounted for.

It is also shown that, in order to render Rankine's formula applicable to wire-drawing experiments, it is necessary that the wire-drawing should be continued till the steam is gaseous, whence arises the difficulty of securing that this state has been reached. This, however, may be secured by lowering the pressure gradually after wire-drawing, and so increasing the extent of wire-drawing while observing the temperature ($T_s°$), which, after falling, will gradually become constant as the wire-drawing

increases, and, when constant, will be a definite indication of this gaseous state.

The necessary conditions to ensuring accuracy are then considered, and, in conclusion, it is stated that a research to verify these conclusions has been commenced by Mr. J. H. Grindley, B.Sc., in the Engineering Laboratory of Owens College, Manchester.

10. *Temperature in Geissler tubes.*—Mr. R. W. Wood has carried out a series of measurements in such tubes. The form of tube permitted a bolometer wire to be moved from point to point. The tubes were excited by 600 Planté cells, which gave about 1,250 volts. The electric current was measured by a torsion galvanometer and its strength regulated by a resistance which consisted of a glass tube filled with a solution of iod-cadmium in amyl alcohol. The tubes were filled, in most cases, with nitrogen, although hydrogen tubes were also used. With hydrogen under a pressure of $1{\cdot}8^{mm}$ and a current of 0·0015 ampere, a rise of temperature of 2·5° was observed. Nitrogen under similar conditions gave a rise of 21·7°. Curves are given of the run of temperature in the stratifications, and in the anode light.—*Ann. der Physik. und Chemie*, No. 10, 1896, pp. 238–251. J. T.

11. *Images in the field of a Crookes tube;* by N. Oumoff and A. Samoïloff.—The influence exercised by a Crookes tube on electrified bodies shows that the electric field created in the interior of the tube extends also to the exterior. To study this exterior action the authors replaced the photographic plate by a plate of ebonite. After excitation of the tube the ebonite is quickly withdrawn and the objects placed upon it are thrown off, and the plate is then sprinkled with a mixture of sulphur and minium. The sulphur adheres to the portions which are positively electrified, and the minium to those which are negatively electrified. Thus the color of the spots shows the electric condition of the shadows, and the modifications in the exterior electric field. It was found that the duration of the action of the Crookes tube has an influence on the clearness and intensity of the image. The authors prove that the yellow color of the image corresponds to the parts of the figure directly attacked by the X-rays, the red color to the images of the objects, and the neutral bands to the shadows which surround the images in certain cases. The authors attribute the effects observed to electric fluxes proceeding from the tubes and the objects in its neighborhood, together with a dielectric polarization.—*Phil. Mag.*, October, 1896, pp. 308–314. J. T.

12. *Röntgen rays.*—It has been suspected by various observers that there are different kinds of X-rays. At a late meeting of the Royal Academy of Sciences, Amsterdam, Professor Haga exhibited two negatives which apparently showed the existence of several kinds of X-rays. At a high degree of rarefaction in the Crookes tubes the penetrating power of the rays through flesh and bone is very different, so that the outlines of the bones are

very distinct; whilst with less rarefaction, these two bodies transmit the rays in about the same degree (Nature, Oct. 29, 1896). It is thought, however, by certain observers that the bones become phosphorescent under certain energy of excitation, and therefore the field of view exhibits less contrasts. It has been discovered that fluorescent screens in order to be of use should not be phosphorescent: for this residual phosphorescence renders the contrast between bones and flesh less evident. A determination of the wave-length of the X-rays has been made by L. Fomm (Ann. der Physik und Chemie, No. 10, 1896, p. 350). He obtained through a slit evidences of interference phenomena similar to those observed in the case of ordinary short waves of light, and by means of a formula given by Dr. V. Lommel for the case of such interference phenomena he obtained the wave length $\lambda = 0{\cdot}000014^{mm}$. This wave length is at least fifteen times smaller than the shortest hitherto observed wave length of ultra violet light. A. Winkelman and K. Straubel (Ann. der Physik und Chemie, No. 10, 1896, p. 324) call attention to the remarkable sensitiveness of fluorspar to the X-rays. The portion of a photographic plate beneath a plate of this mineral which is exposed to the X-rays becomes as black as if it were submitted to direct daylight. Unfortunately it is impossible to procure large plates of fluorspar to cover photographic plates. When the mineral is pulverized and sifted on a sensitive plate it does not seem to act as well as when it is in moderate-sized pieces. The use, however, of large pieces mottles the sensitive plates and destroys the definition of objects photographed on it. J. T.

13. *The Principles of the Transformer;* by FREDERICK BEDELL, PH.D. xii + 404 pp. New York, 1896 (The Macmillan Company).—This book is, in a measure, a continuation of Bedell and Crehore's "Alternate Currents," and is similar to it in general aim and methods of treatment. The same clearness of reasoning and lucidity of style which have justly rendered the previous work popular among students are apparent in this volume also. Occasionally, however, the desire for clearness in demonstration seems to have led the author almost to the verge of prolixity; for example, it is difficult to see the utility of such minute detail in the treatment of the general equations of the transformer in Chapter XI; it can hardly make the subject intelligible to those readers who have no acquaintance with determinants or elementary differential equations, and is, on the other hand, scarcely necessary for those whose mathematical studies have included these subjects.

A dual method of treatment is adopted, many of the problems being solved by analytical treatment, and also graphically by means of the polar diagram. In the first twelve chapters the theory of the transformer with constant coefficients of induction is gradually developed with greater and greater generality; then follow several special problems, and chapters on design and construction, experimental diagrams and transformer testing. The

final chapter is upon the effects of hysteresis and Foucault currents; it is to be regretted that this portion of the subject has not been treated at greater length.

One admirable feature of the book is the adoption of a consistent notation throughout, and the collection of the symbols used, with their definitions, in a separate chapter. In this connection a sentence or two may be quoted from the author's preface, which will probably command the approbation of most readers who object to the abuse of their mother-tongue even in technical periodicals. "Over-abbreviation and the introduction of heterogeneous prefixes and suffixes *ad libitum* the author views as a mania of the day, which proves a source of confusion rather than an aid to the reader. . . . . The introduction of new terms and units has been carefully avoided."

Altogether the work deserves commendation and can scarcely fail to be of great use to students of electricity.

14. *The Elements of Physics, Vol II. Electricity and Magnetism;* by EDWARD L. NICHOLS and WILLIAM S. FRANKLIN. pp. ix + 261. New York (The Macmillan Co.).—It has evidently been the intention of the authors, in this book, to reduce the important laws governing electrical quantities to mathematical expressions, rather than to prepare a comprehensive text-book of electricity. The volume may be not unfairly described as a rather full note-book on the mathematical theory of electricity and magnetism. It opens with an introductory chapter on the treatment of distributed quantities. The ideas and analytical methods presented here are much more difficult than those used elsewhere throughout the book.

The order of treatment is unusual. The fundamental concept is a magnet which is thus defined (Art 327, a.): "A bar of steel which has been treated in a manner to be described later is called a magnet." From this definition are developed the usual expressions for the magnetic quantities, but how the bar of steel was treated is nowhere explicitly stated. The electric current is then defined by the equation $F = Ilf$, where F is the sidewise push on a wire of length l in a field of strength f, and later an electric charge, as the time integral of the current. After a discussion of electrolysis, batteries and resistance, charge is again introduced in the chapter on Electrostatics and defined by Coulomb's law, as if it were an independent quantity. Succeeding chapters discuss phenomena of discharge, magnetism in iron, induced electromotive force, thermo-electric currents, practical applications, and mechanical conceptions of the electric and magnetic fields.

The diagrams are numerous, simple and clear. A little more care should have been exercised in the order of presentation. Terms and instruments are often introduced before they have been defined, or described; e. g. current p. 31*e*, battery p. 66, induction coil p. 168. Equations 213 and 238 contain errors for which the proof-reader is to blame. There are numerous examples of careless writing. In Art 359 a galvanometer is said

to "depend on equation 204 for its action." In Art 517 we read of the "flow of magnetic flux." In Art. 582, equation 2 is ascribed to Cavendish but in Art. 330 to Coulomb. The numerical value of the velocity of light is virtually given in four different ways, 300·2, 298, 300, and 299 million meters per second.

15. *Alternating Currents and Alternating Current Machinery;* by DUGALD C. JACKSON, C.E., and JOHN PRICE JACKSON, M.E. pp. xviii and 729. New York (The Macmillan Co.).—This book forms the second volume of Jackson's Text-Book on Electro-Magnetism and the Construction of Dynamos. It is a work intended for the use of students of electrical engineering. In so far as we may judge, without having put the book to actual test in the designing room, the authors have well fulfilled their aim to develop a clear exposition of the principles governing the design of electro-magnetic machinery, and present the elements of present engineering practice. The style is concise but never scrappy. Whenever theory can serve as a guide in the construction of a machine and mathematics is necessary, it is introduced, the necessary formulas being derived from the beginning. Difficulties are not slurred over nor, on the other hand, does the book have the peculiar character of a mathematical treatise. For the more purely empirical parts of the subject numerous tables are introduced. A large number of diagrams and line drawings serve to illustrate the text, but mere pictures of commercial machinery have been excluded. Methods of measuring the various magnetic quantities, and of testing alternators and transformers, are described at length.

On casual reading there appear very few things indeed that suggest adverse criticism. The classification of armatures (p. 15) seems artificial and of little value. The sentence (p. 78) "All insulated conductors have the property of being able to hold electricity in its static form," might lead the reader to infer that electricity existed in different forms, one of which is known as the static. On the whole the book may be said to be an excellent one for the sphere for which it was written.

II. GEOLOGY AND MINERALOGY.

1. *On some Palæozoic fossils from Baffinland;* by E. M. KINDLE. (Communicated.)—During the past summer the writer obtained, while with the Cornell University Arctic Expedition, two small collections of fossils from Baffinland. The first of these was collected from the mainland north of Hudson Strait, about lat. 62° 45′ and long. 70° W., and from Big Island. The other set of specimens was collected by Mr. Peck, a missionary, who obtained them from the shores of Lake Kennedy, which lies northwest of the head of Cumberland Sound. All of the specimens from Big Island and Hudson Strait were picked up from the drift. These are embedded in hard, fine-grained, light-gray limestone, which occurs in small fragments very sparingly dis-

tributed among the gneiss boulders which everywhere encumber the surface. Sections of *Crinoid stems* occur abundantly in these limestone fragments. Associated with them are several specimens of *Zaphrentis*. These are not sufficiently well preserved to admit of specific identification.

Aside, however, from the little interest which the few poorly-preserved specimens from Big Island may have as fossils, they are worthy of mention because of their relation to the glacial history of the island. Big Island has a north and south diameter of about fifteen miles, and is separated from the mainland by White Strait, which is from three to ten miles wide. The Island, which is now free from ice, presents everywhere evidence of former glaciation. The observations of Mr. T. L. Watson and Mr. J. A. Bonesteel, who spent three days exploring the island, indicate that no limestone beds occur on it. It would seem, therefore, that the limestone erratics picked up on the Island, as well as those from the coast of the mainland, were derived from the interior of Baffinland, probably from the region above Frobisher Bay, where Capt. Hall found a limestone formation. From the mainland they were probably transported by an ice cap, which extended across White Strait and enveloped Big Island, to the position where they were found.

From the Lake Kennedy specimens, all of which appear to be from the same limestone, I have recognized the following species:

Zaphrentis, sp.?
Halysites catenulatus Linn.
Maclurea magna Hall?
Endoceras proteiforme Hall.

Zaphrentis is a wide-ranging genus and is, therefore, of no value for purposes of correlation. *Maclurea magna* and *Endoceras proteiforme* are both Ordovician species occurring in the Trenton. *Halysites catenulatus*, however, is generally regarded as a characteristic Niagara form, although it has been reported from the Ordovician.* This association of Silurian and Ordovician species may have resulted from the mixing of specimens originally from distinct horizons, but, on the other hand it may express an association in a common fauna of species, which in other regions were restricted to different geological horizons.

2. *United States Geological Survey, 16th Annual Report, Part I, Director's report and papers of a theoretic nature:* C. D. Walcott, Director, pp. i–xxii, 1–910, plates i–cxvii, figs. 1–168. Washington, 1896.—This latest published of the four large volumes of the sixteenth annual report contains several papers of special importance:

"The Dinosaurs of North America," by O. C. Marsh, will receive special notice elsewhere. "Principles of North American pre-Cambrian geology," by Chas. R. Van Hise, with an appendix by Leander M. Hoskins, has been presented in an abstract by the

* Jour. Cin. Soc. Nat. Hist., vol. xviii, Nos. 3 and 4, p. 165.

authors on pages 205–213 of this volume. Mr. Dale's paper on "Structural details in the Green Mountain region," is described on page 395. Mr. Harry Fielding Reid contributes an illustrated report on "Glacier Bay and its glaciers," with numerous important statistics regarding the general features and the changes now going on in this Alaskan glacier region.

In the paper "Some analogies on the lower Cretaceous of Europe and America," the author, Lester F. Ward, in the first part makes comparison of the Potomac formation with that of the Wealden of England, and finds reason for considering them closely related as indicated by their respective floras; secondly, the scaly clays of Italy, their cycads and the age of the beds are discussed; and thirdly, the Jurassic and Cretaceous floras of Portugal are compared with the corresponding floras of America.

3. *Biological Lectures, Wood's Holl, summer season of* 1895. pp. 1–188, 1896—The latest number of this series contains several papers of general interest.

Two of the lectures were on the head segments of vertebrates. William A. Lacy in "The primary segmentation of the vertebrate head," reaches the conclusion that there are normally fourteen neural segments. He says: "The human brain is not a homogenous mass of tissues, but a *complex* compound of an aggregation of about fourteen brains all united into a working whole." Professor G. S. Kingsley, in the following lecture, on "The segmentation of the head," after noting the varying interpretations of previous investigators, accepts the observations of Mr. Lacy as to matters of fact, but hesitates to adopt his interpretation, remarking that "while we can say that there are certainly more than the three or four segments of Oken and his followers, we cannot say exactly what the number is. Before the answer is placed beyond a doubt, a number of other questions must be solved, not the least of which is the broader problem of the origin of metamerism and the relation of this condition in the vertebrates to that in the lower forms." Significant, as bearing upon this latter suggestion, is the recent address of Dr. Gaskell, before the physiological section of the British Association this summer, on the "origin of vertebrates," in which he traces it to the merostomata, chiefly by means of the neural segmentation.

Another investigation presented in the Wood's Holl series is on "the transformation of Sporophyllary to vegetative organs," by Professor George F. Atkinson. The author observes the remarkable facility with which the normally differentiated sterile and fertile leaves of the *Onoclea sensibilis* replace one another. He draws the conclusion that the sporophylls are primary organs, here agreeing with Bower, and are transformed into vegetative leaves. Aside from this special result of the investigation, the remarkable variability in the degree of differentiation of the two kinds of leaves is a warning, especially to paleobotanists, against drawing too hasty generalization from the separate fragments of fossil ferns met with in the rocks.

Professor W. B. Scott, in the lecture on "Paleontology as a Morphological Discipline," though presenting no original investigations, appropriately calls the attention of biologists to the importance of paleontological studies toward the solution of the perplexing problems of biology. He mentions "one or two principles which stand out with especial clearness as the deductions drawn from paleontological study of phylogenetic series. These are (a) "Evolution is ordinarily a continuous process of change by means of small gradations," although "this does not imply that the rate of change was always uniform,—it probably was not,—or that a sudden alteration of conditions may not bring about discontinuity, or *per saltum* development."

(b) "Development is, in most instances, direct and unswerving." . . . .

(c) "Parallelism and convergence of development are much more general and important modes of evolution than is commonly supposed. By parallelism is meant independent acquisition of similar structure in forms which are themselves nearly related, and by convergence such acquisition in forms which are not closely related." This observation leads the author to "emphasize the necessity of founding schemes of classification upon the totality of structure, and of determining the value of characteristics, whether they are primitive or acquired, divergent, parallel, or convergent, before attempting to assign them their proper toxonomic value." H. S. W.

4. *The Dinosaurs of North America;* by O. C. Marsh. Extract from the Sixteenth Annual Report of the U. S. Geological Survey, pp. 133–414, 66 cuts in text, plates ii–lxxxv. Washington, 1896.—The Dinosaurs are by far the most prominent group of vertebrates of geologic times, excelling all other groups, not only in size, but also in degree of specialization. Their development is confined strictly within the limits of the Mesozoic, and, therefore, in tracing their history through the Triassic, Jurassic, and Cretaceous, their rise, culmination, decline, and extinction are fully recorded.

In the present memoir, the arrangement of the subject is mainly geological. The Dinosaurs are recognized as a subclass, embracing the three orders *Theropoda*, *Sauropoda*, and *Predentata*. Of these, the first were carnivores and the others herbivores. The *Predentata* are again divided into three suborders: (*a*) the *Stegosauria*, Dinosaurs more or less protected with dermal plates; (*b*) the *Ceratopsia*, huge horned forms; and (*c*) the *Ornithopoda*, Dinosaurs with bird-like characters.

In the Triassic, all the best-known species belong to the carnivorous order *Theropoda*. Abundant evidences of the herbivorous forms are found in the footprints so common in the Connecticut sandstone, but as yet no distinctive teeth or bones have been discovered there.

Among the Jurassic Dinosaurs, the diminutive *Hallopus*, the small *Cœlurus*, and the ferocious *Allosaurus* and *Ceratosaurus* are

the chief representatives of the *Theropoda*. The order *Sauropoda* is confined to the Jurassic, and contains some most striking forms. Among them, *Atlantosaurus*, *Brontosaurus*, *Apatosaurus*, *Diplodocus*, and *Morosaurus* are remarkable for their huge size. The *Predentata* of the Jurassic include the well-known *Stegosaurus*, and the bird-footed genera *Camptosaurus*, *Laosaurus*, and the smallest of known Dinosaurs, *Nanosaurus*.

Dinosaurs were still abundant in the Cretaceous, and in general were more highly specialized than in the preceding formations. *Ornithomimus*, with its bird-like feet and the coössified pelvic arch, is one of the most important carnivores. The main interest in the Cretaceous Dinosaurs centers about the most remarkable group of gigantic, horned *Predentata*, known as the *Ceratopsidæ*, including *Triceratops*, *Ceratops*, *Torosaurus*, *Sterrholophus*, *Agathaumas*, *Polyonax*, and *Monoclonius*. The remaining herbivorous forms include the *Claosauridæ*, *Trachodontidæ* (*Hadrosauridæ*), and *Nodosauridæ*.

The more important bones of the skeleton of each type are fully illustrated, and the best-known forms are represented by complete restorations: such as *Anchisaurus* of the Triassic; *Ceratosaurus*, *Brontosaurus*, *Stegosaurus*, *Camptosaurus*, and *Laosaurus*, of the Jurassic; and *Triceratops* and *Claosaurus* of the Cretaceous.

Restorations of four leading types of European Dinosaurs are introduced for comparison: *Compsognathus*, a small carnivore; *Scelidosaurus*, a herbivorous form related to *Stegosaurus*; *Hysilophodon*, related to *Laosaurus*; and *Iguanodon*.

A separate chapter is devoted to the affinities of the Dinosaurs, and homologies are established with the *Aëtosauria*, the *Belodontia*, the *Crocodilia*, and with Birds. In the concluding chapter, a classification of the entire group is presented.

C. E. B.

5. *Manual of Determinative Mineralogy with an introduction on Blow-pipe Analysis*; by GEO. J BRUSH, *revised and enlarged* by SAMUEL L. PENFIELD, 8vo, 163 pp., 33 tables. New York, (Wiley & Sons), 1896.—That this well know work has been appreciated by the public is shown by the fact that the present is the fourteenth edition since its appearance in 1874. The present edition by Prof. Penfield is not, however, a merely formal one; on the contrary, the book, while retaining all the features which have characterized and given it its value, has been for the most part rewritten, and considerably enlarged. Especially valuable to teachers and self-students will be found the chapter on the reactions of the elements; many new methods of testing are here added. The distinguishing feature of the work is its eminently practical character; in all cases the most simple, useful and decisive methods are given; there is no padding with descriptions of complicated methods or those which have only a theoretic interest. The suggestions given under the experiments will be of great value. The work throughout shows that it comes at first

hand from the teacher and investigator, and nowhere does one find the vagaries of indiscriminate compilation, which are an all too common fault in books of this character. The tables are those of the former edition, but a revision of them also is promised for the near future. L. V. P.

6. *Mikroskopische Physiographie der massigen Gesteine von* H. ROSENBUSCH. 3d ed. enlarged and revised, 8vo, second half, pp. 553–1360. Stuttgart 1896.—The appearance of the new edition of this well known work has already been noticed in this Journal (vol. i, p. 63, 1896); the issuance of the second part completes it. The present part contains the effusive rocks, in which the age distinction in classification is retained. The later rocks are, however, described first as being the most typical, and it is clear that the author does not attach the importance to age that the separation in the book would seem to imply. The important group of diabases are described in this part. New matter has been everywhere added and the subject dealt with critically to date. The excellent indices are especially to be commended, greatly aiding as they do in ready reference. It is to be regretted that the size of the volume necessitated the omission of the general index to the literature, which was so serviceable a feature of the previous editions. L. V. P.

7. *Die Minerale des Harzes*, eine auf fremden und eigenen Beobachtungen beruhende Zusammenstellung der von unserem heimischen Gebirge bekannt gewordenen Minerale und Gesteinsarten von DR. OTTO LUEDECKE. 643 pp. with an altas. Berlin, 1896 (Gebrüder Borntraeger).—The mining region of the Harz Mountains in Germany is one that has long been classical in the study of mineralogy, remarkable both for the number of the species it has afforded and for the perfection in which many of them have been found. The author states that he has devoted himself to the study of this region since 1880, and in addition to his own extensive collections he has had the use of a number of other collections, public and private; the material at his disposal has thus been very large. The results of his labors, in part previously published, are given in this large volume. To his own observations he adds also a summary of the earlier literature and of the work of other mineralogists, and the volume thus becomes a complete monograph of a series of most important mineral localities. The species are arranged according to the usual chemical classification and under each is given a minute account of its crystallization, method of occurrence and association with other species. In special cases, as for example with galena and chalcopyrite, the feldspars, etc., a more minute geological description is given of the particular regions involved, as also of the associated rocks.

The thoroughness with which the author has performed his work, and the admirable way in which the whole is presented, makes the volume one of very great value. A series of some twenty-seven plates give figures of notable species, with spher-

ical projections in many cases, a chart of the whole region showing all the mineral veins is added and special ones for Clausthal and Andreasberg.

8. *Minéralogie de la France et ses colonies;* description physique et chimique des minéraux; étude des conditions géologiques de leur gisements, par A. LACROIX; tome deuxième, 1re partie, 352 pp.; Paris, 1896 (Baudry et Cie.).—The part now published of the *Mineralogy of France* forms the first portion of the second volume, and is largely given up to a description of the feldspars, including also the zeolites and related species. The special character of this admirable work has been dwelt upon in the notices of the volume which have appeared earlier. The author states that the work has grown on his hands and that when completed it will include another volume beyond what was previously promised. The minute description of the occurrence of the different species which each locality considered gives the work a unique character among mineralogical publications. The fact that the author has himself visited the greater part of the localities mentioned has enabled him not only to present many new facts, but to give a detailed and thorough account of each occurrence with the special geological conditions characterizing it. The work is hence quite as interesting and important for the geologist as the mineralogist.

9. *The Vienna Collection of Meteorites.* — The tenth volume of the "Annalen des K. K. naturhistorischen Hofmuseums" contains an exhaustive account of the collection of meteorites at the Vienna Museum, prepared by Dr. Brezina, until recently the Custos. The collection is probably the largest and most richly represented among those in the great museums of the world. The number of separate occurrences recorded is 498, and the list includes about 60 more which are not represented at Vienna. Many of the specimens are of extraordinary interest and not a few are entirely unique, as for example, the iron of Mazapil, Mexico, and that of Cabin Creek, Arkansas, both purchased from collectors in this country.

As the result of his study of meteorites, Dr. Brezina classifies them into the two grand groups, I, of the stony meteorites, and II, of iron meteorites, according as to whether the silicates or the metallic constituents predominate. Further, he recognizes under these groups six sub-groups, with a seventh which is intermediate between them. He names them as follows: A. Achondrites, including stones with but little iron and in which the chondrules are essentially absent. B. Chondrites, consisting of bronzite, olivine, and nickel-iron with round or polyhedral chondrules. The third sub-group, C. Siderolithe, forms the transition to the irons, including those in which olivine and bronzite are prominently present and in a cross-section seem to separate the iron into individual grains. Under the iron meteorites we have next D. Lithosiderites, in which silicates in the form of crystalline grains are imbedded in a continuous mass of iron (here fall the

pallasites). Further, E. Octahedrites, or irons with octahedral structure; F. Hexahedrites or cubic irons, and finally, G. Ataxites, or those in which the iron is closely compact and does not show the crystalline structure characteristic of E and F. These groups are further divided into sixty-one classes, under each of which the specimens belonging to it are given and its peculiar features described, often with illustrations. This catalogue is a highly important contribution to our knowledge of meteorites in general.

10. *Phosphate deposits in Tennessee.*—Prof. J. M. SAFFORD has recently described a new occurrence of phosphate rock in Central Tennessee, which promises to be of much economic importance. The locality now opened is in the town of Mt. Pleasant, in Maury County, where the phosphate is found in banks from three to eight feet in vertical thickness. The rock is light yellowish or grayish in color, of an open, spongy structure, and occurs in layers or plates from one to six inches or more in thickness piled together in stratified masses. Analyses show that it consists of from 60% to 80% of calcium phosphate, with calcium carbonate, etc.

This phosphate rock has been derived from limestone of Trenton age, particularly the "Capitol limestone," through a long continued process of leaching by carbonated waters, which have dissolved away the calcium carbonate and left the less soluble layers of phosphate. The source of the phosphate in the original limestone is yet in doubt.—*Amer. Geol.*, Oct. 1, 1896.

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11. *National Academy of Sciences.*—The following is a list of the papers presented for reading at the meeting of the Academy held at New York, Nov. 17 and 18:

A. MICHAEL: On certain positive-negative laws in their relation to organic chemistry.

O. C. MARSH: The Jurassic formation on the Atlantic coast.

IRA REMSEN: The hydrolysis of acid amides. The isomeric chlorides of paranitroorthosulphobenzoic acid.

ALFRED M. MAYER: The equations of the forces acting in the flotation of disks and rings of metal, with experiments showing the floating of loaded disks and rings of metal on water and on other liquids.

E. D. COPE: On the geographical distribution of Batrachia and Reptilia in the Medicolumbian region.

S. NEWCOMB: On the physical causes of the periodic variations of latitude. On the solar motion as a gauge of stellar distances.

C. A. WHITE: Memoir of F. B. Meek.

A. E. VERRILL: The evolution and pylogeny of Gastropod Mollusca.

O. N. ROOD: On flicker photometers.

C. S. HASTINGS: A new type of telescope free from secondary color.

C. S. PEIRCE: A graphical method of logic. Mathematical infinity.

III. Botany.

1. *The Timber Pines of the Southern United States;* by Charles Mohr, Ph.D. Prepared under the direction of B. E. Fernow, Chief of the Division of Forestry, U. S. Dep. of Agriculture, Washington, D. C. 1896.

Four species of pines in our Southern States possess a high degree of interest from an economic point of view. It is to these pines that we look for a large part of our supply of lumber, especially as the threatened diminution of our northern resources is already upon us. In these pineries prompt application of sound principles of forestry may check unnecessary waste and bring permanent thrift where one can now see little but prodigal and irrational treatment.

It is difficult to see how the importance of this question can be brought fairly before those who are primarily concerned in lumbering operations. The lumberman is so apt to regard his forests as a source of immediate profit, that he finds it almost impossible to treat them as a source of permanent income. In some instances he would indeed be willing to exchange the larger immediate profit for the smaller permanent income, but he knows that under existing conditions there are risks, like that of fire, for instance, which lessen the stability of his investment. And therefore even the cautious and far-seeing lumberman takes the bird in the hand instead of the possible two in the bush. Conditions of scientific lumbering at the south are more favorable than at the north, but scientific lumbering is not forestry. The forester is the husbandman of wood crops: the lumberman is merely a harvester. The question is, therefore, how can the harvester be made to see that it is for his interest to take part in the care as well as the cutting. Professor Fernow, the chief of the Forestry Division of the Department of Agriculture, has deemed it wise to bring to the attention of the owner of the southern pineries Dr. Mohr's monograph on the life-history of the five principal species, supplementing this by an account of the structure of the wood by Mr. Roth. Of course we cannot say that the experiment will be any more successful than a hundred others which have been undertaken in Forestry instruction, but we can say that the experiment ought to succeed, and we give it our best wishes.

The monographs are valuable contributions to our knowledge of the subject and should serve a good purpose. Dr. Mohr has displayed great energy in his accumulation of material and excellent judgment in its treatment. We wish it might be possible for him to continue his exhaustive and scholarly studies in similar directions until all our timber trees of economic importance are as well understood as these five which he and Mr. Roth have examined so thoroughly.

The sumptuous work on our native trees by Professor Sargent,

"The Silva," now publishing, deals to some extent with the economic aspects of our timber trees and in a judicious manner. Such treatises as that by Dr. Mohr supplement "The Silva" in the best possible way, and make, with that, a firm basis for a wise and fruitful Forestry. G. L. G.

2. *Richards on increase of activity in respiration after injury.*—Professor PFEFFER gave, at the July session of the Leipzig Academy, an account of certain experiments on living plants conducted by Dr. H. M. Richards, in his laboratory. These traumatic reactions both as regards respiration and temperature are decided. Dr. Richards has taken up the subject about where it was left by Böhm and Stich, and has made substantial additions to our knowledge. The most telling experiments were performed on fleshy and rather fully developed organs, where as a consequence of wounds, there would be an increase in the rate of respiration amounting to even twenty fold. G. L. G.

OBITUARY.

BARON FERDINAND VON MUELLER, K.C.M.G., Government Botanist of Victoria, died at Melbourne on October 9th, in his seventy-second year. After completing his studies at Kiel, he went to Australia, very largely on account of his health, and soon engaged in the exploration of his new home. His tastes led him early to collect and examine the plants of Australia, and to this task he devoted the remainder of his life. He took particular interest in the economic advancement of his own colony and contributed much to this phase of development in all parts of Australia. His voluminous writings have enriched almost every department of botany and constitute an enduring monument. The present writer made the Baron's personal acquaintance in Melbourne in December 1890, and from that date to this has had very frequent opportunities of noting the goodness of heart by which all controversies were tempered. The Baron felt himself deeply aggrieved at his treatment at the hands of certain public officials in the Colony, but this did not prevent his devoting all of his slender means and all his energies to what he regarded sound and healthy development of his adopted land.

It is pleasant to note that his scientific associates in Australasia, although differing widely from him as to many questions of public policy and scientific interpretation, willingly paid him the honor of electing him in 1889 the presidency of their Association for the Advancement of Science. At the next meeting of the Association, at Christ Church, New Zealand, Baron Mueller had the deep satisfaction of renewing friendly relations with some from whom he had been long estranged, and from that period to the end of his useful life, his arduous labors were lightened by additional reconciliations. Much if not all the old bitterness of real and fancied wrongs had passed away. G. L. G.

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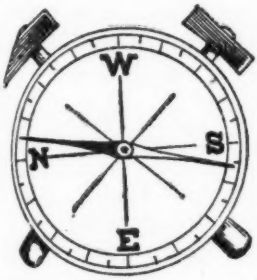

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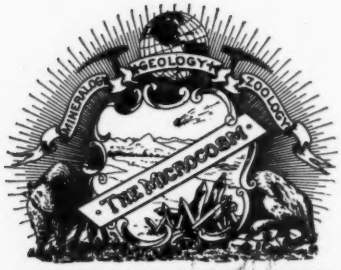

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(1) Described in this Journal Sept., 1895. (2) Ibid Nov., 1887. (3) Proc. Roch. Acad. Sci., Vol. 1. (4) This Journal Aug., 1888. (5) Ibid July, 1893. (6) Ibid June, 1894.

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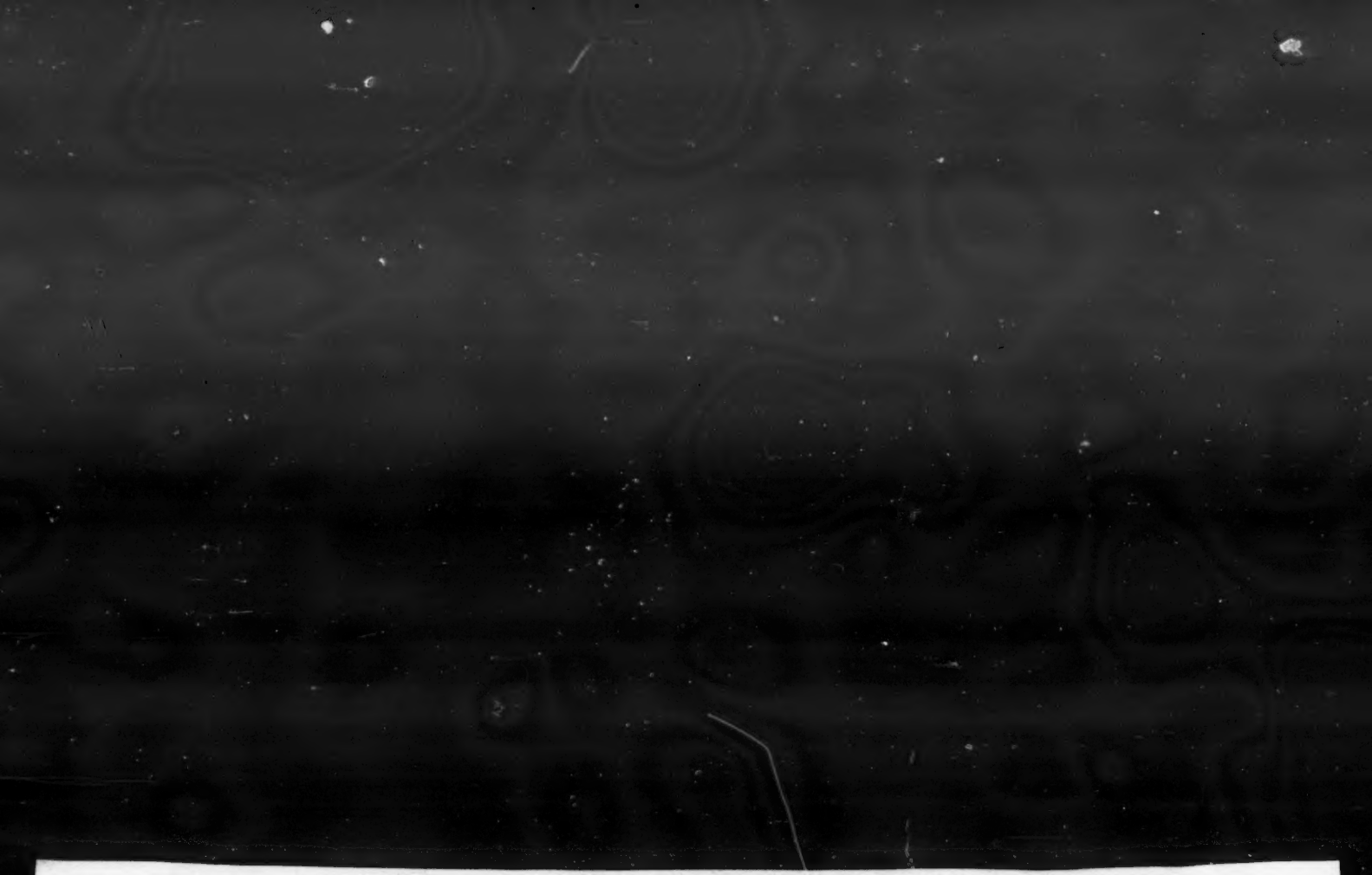
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